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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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The following information must accompany each offer, which must be addressed to Mr. HUBERT BAINES, Deputy Chief Engineer, H.M. Office of Works, King Charles Street, Whitehall, London, S.W.:—Type, size and weight; maker's name; when built; when and by whom last overhauled; condition; price.

H.M. Office of Works, &c.,
20th November, 1916. F 627

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

2099 Ordinary Shares of £1 each, fully paid, in THE FLOTTMANN ENGINEERING COMPANY, LIMITED, vested in him as Custodian by an Order of the Board of Trade dated the 3rd August, 1916.

The issued Capital of the Company consists of 2100 Ordinary Shares of £1 each, fully paid.

Under the Company's Articles of Association, every Member has one vote for every share held by him or her.

The Purchaser will be required to make a sworn declaration as to nationality and freedom from foreign control, on a form to be obtained from the Offices of the Public Trustee.

The Company owns leasehold works at Cardiff equipped for the manufacture of Flottmann Compressed Air Hammer Drills, &c., but is at present mainly engaged on Munition Work as a Controlled Establishment.

A report upon the result of the past operations and the present position of the Company has been made to the Public Trustee by Messrs. SHEPHERD, HOWELL & Co., Chartered Accountants, Cardiff, and this report can be inspected by those desirous of tendering, either at the office of the Public Trustee or at that of Messrs. SHEPHERD, HOWELL & Co.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, London, W.C., on or before Friday, the 15th December, 1916, at Twelve noon, marked on the envelope, "Tender, Flottmann Shares," and successful tenderers will be advised of the acceptance in whole or part of their Tender within one week thereafter.

Tender may be made for the whole or part of the Shares.

The Public Trustee does not bind himself to accept the highest or any Tender, and reserves to himself the liberty to allot shares to several tenderers as he thinks fit.

Forms of Tender can be obtained from the PUBLIC TRUSTEE, or from Messrs. SHEPHERD, HOWELL AND CO., Gresham Chambers, Kingsway, Cardiff. F 619

APPOINTMENTS OPEN.

IMPORTANT POSITION VACANT.

First-class Works' Managers

are invited to apply for VACANCY which will shortly occur in a large Government controlled Engineering Works having foundries, machine shops and erecting bays, specialising in high-class work of repetition nature, both small and large. The appointment is an important one, and a high salary offered accordingly. Applicants must have wide experience in works organisation and up-to-date methods, be strict disciplinarian, and able to secure maximum output; must have successfully filled similar position in Engineering Works of not less than two or three thousand hands.

Address, in first instance, giving full particulars, which will be treated as confidential, P 509, Offices of ENGINEERING.

Works' Manager Required

for Government controlled firm, to take charge of new extensions in course of erection. Must be able to see that erection of buildings and putting down of machine plant is accomplished with the utmost speed, and be conversant with the latest up-to-date machine practice for taking control of the extensions when completed; also must be able to take charge of a large body of men and maintain strict discipline. Only first-class energetic man need apply. Applications will be treated as strictly confidential.

Address, F 609, Offices of ENGINEERING.

Works Manager Wanted for

General Engineering Works at present chiefly engaged in shell manufacture and employing about 500 hands. Must be six o'clock man and a capable and efficient manager of men and women workers. Intimate knowledge of modern machine tool practice essential. District near Bristol. Good opening for suitable man. No one at present engaged on War work need apply without permission from present employer.—Write, stating full qualifications, age, and when at liberty, to BOX No. 883, care of Messrs. R. F. WHITE & SON, General Advertising Agents, 33, Fleet Street, E.C. F 573

Wanted Works Manager for

large Aircraft Works making Rotary Engines and Aeroplanes. Must be accustomed to the control of men, and have good machine tool experience, with intimate knowledge of the best means of production. The position is a permanent one, and a liberal salary will be paid. Applications from persons already engaged on Government work will not be considered without permission from present employers.—Address, with full particulars, F 595, Offices of ENGINEERING.

Inspectors Required by

the War Office to undertake inspection and test at manufacturers' works of all kinds of mechanical plant, including steam and oil engines, boilers, machine tools, &c., also of constructional steel work, including tests of materials.

Apply, by letter in the first instance, stating qualifications and terms, to—

THE INSPECTOR OF IRON STRUCTURES,
War Office.

Only men not eligible for military service need apply. F 572

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Engineer Foreman for

Controlled Works; capable of superintending repairs and erection of boiler works plant, and take charge of small fitting shop, making-up pressing, and rolling machinery; one with some knowledge of electric motors, hydraulic presses and gas engines preferred; permanent position to right man. State age, wages, and experience, for Wolverhampton district; no one on Government work need apply.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 586.

Wanted a Foreman Engineer

for Blast Furnaces on the West Coast. Must be capable of indicating and making necessary adjustments to engines; well up in boiler-house plant, and upkeep and efficiency of plant generally. No person already engaged on Government work will be employed.—Apply, with references, stating age, experience, and wages expected, to your nearest LABOUR EMPLOYMENT EXCHANGE, mentioning this Journal and F 602.

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EXPERT REQUIRED to organize new steel foundry, weekly output 60 to 80 tons. Electrical furnaces will be installed, and the work will be mostly repetition work for motor lorries. Replies to give full details as to age, practice experience, and salary required.—F 590, Offices of ENGINEERING.

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REQUIRED in Works engaged on Government Contracts, fully accustomed to latest practice and accurate work on lathes, milling machines, jig-work, &c., for motor car and aeroplane engine parts. No one living more than 10 miles away or working on Government work will be engaged. Only fully competent men need apply with full particulars, wages, &c.—Address, F 581, Offices of ENGINEERING.

Works Engineer for Sheet

Mills in South Staffordshire; must be thoroughly competent in all branches. No person already engaged on Government work will be employed.—Apply, your nearest LABOUR EMPLOYMENT EXCHANGE, mentioning this Journal, and F 607

Refrigerating Engineer

WANTED; experience, with ammonia and first-class Board of Trade Certificate desirable. No one already engaged on Government work or eligible for military service need apply.—Send particulars of experience, with age, and state if married, to "T." BOX 252, T. B. Brown's Advertising Offices, 163, Queen Victoria Street, E.C. F 608

First class and Fully Qualified

Stores ACCOUNTANT WANTED, at once, for large factory. Must be experienced in all duties appertaining to store-keeping and stores accountancy; also accustomed to prime costing. Preference given to applicant holding C.A. or other similar certificate. State full particulars and salary required.—Address, F 541, Offices of ENGINEERING.

Accountant Wanted, for

charge of manufacturing accounts, near London. Must also be fully experienced in cost accounts.—Write, stating age, qualifications, and salary required, to H. H., care of J. W. VICKERS AND CO., Ltd., 5, Nicholas Lane, E.C. F 582

Small Tools.—Indoor Assistant

REQUIRED, experienced in the Sale of British and American Small Tools and Engineering shop requirements generally. Ineligible. Permanency. No person resident more than 10 miles away or employed on Government work will be engaged.

Write stating age, experience, salary, to JAMES W. CARR & CO., Ltd., 35, Queen Victoria Street, London, E.C. Replies private and confidential, and as such they will be treated. F 580

Wanted, by a London Electric

Supply Co., an ASSISTANT ENGINEER, to take charge of a watch at one of their stations. Must be ineligible for the army.—Address, stating age, experience, and enclosing copy of recent testimonials, F 466, Offices of ENGINEERING.

Young Engineer with Work-

SHOP Training and Science Degree WANTED for technical work in large instrument making factory. No one engaged on Government munition work or eligible for military service should apply. State age, experience and salary required. —Apply your nearest EMPLOYMENT EXCHANGE mentioning No. A 2034. F 631

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for works in S.E. district. No person resident more than 10 miles away, or already engaged on Government work need apply.—Address, F 604, Offices of ENGINEERING.

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Laboratory, workshop, and teaching experience desirable.

Salary, £150 per annum.

Further particulars may be obtained from the undersigned.

Applications, together with two testimonials, to be sent in before the 9th December, 1916.

J. G. TAYLOR,
Secretary.

Education Offices,
West Hartlepool,
27th November, 1916. F 591

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1917,

Appoint a Few Natives

of India as ASSISTANT ENGINEERS in the Indian Public Works and State Railway Departments.

Candidates must be British subjects, and, save as provided in Appendix III to the Regulations, must be not less than 21 and not more than 24 years of age on the 1st July, 1917. They must have either obtained one of certain recognised University degrees or other distinctions in Engineering, or have passed the Associate Membership Examination of the Institution of Civil Engineers.

Applications must reach the India Office by 31st March, 1917. Printed Forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, London, S.W.

India Office, London.
December, 1916. F 621

Good Engineering Draughtsman

WANTED by controlled firm, Liverpool. Knowledge ship repairing an advantage. No one already engaged on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 547.

Draughtsman, British,

thoroughly conversant with mechanical and electrical machine construction, REQUIRED, to take charge of Engineer's drawing office, Westminster. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 576.

Wanted, Three Draughtsmen

thoroughly conversant with either Blast Furnace or Steel Works practice, for large Government controlled Iron and Steel Works on the North West Coast. Permanency to suitable men.—Applications should be forwarded to the nearest LABOUR EXCHANGE, quoting No. A 2822. Draughtsmen already engaged on Government work cannot be engaged. F 594

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in automobile work and with a sound knowledge of gears, REQUIRED for the Designing Department of a aircraft in N.W. London.—Apply, stating age, experience (in detail), and salary required to F 598, Offices of ENGINEERING. No one at present engaged on Government work, or residing over 10 miles distant will be accepted.

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WANTED, for Marine Auxiliary Machinery. State experience and wages expected. No person already engaged on Government work or residing more than 10 miles away need apply.—Apply by letter, to CAIRD & RAYNER, 777, Commercial Road, Limehouse, E. F 593

Wanted Lady Tracers, or

with experience in Detail Drawing, &c., must be quick and accurate. No one employed on Government work will be entertained.—Please apply to the nearest EMPLOYMENT EXCHANGE, sending full particulars and sample of work, mentioning this Journal and F 550.

Required for the Service

of the Government of India, a FOREMAN for the Hardening Section of the Rifle Factory, Ishapore.

Candidates should be about 30 years of age. They must be physically fit for service in India and should have had workshop experience in the heat treatment of steel. They must make sure that they could be released from their present employment if selected.

TERMS.—Engagement for Five years, with option of extension if approved by Government. Salary 350 rupees per month, rising by annual increments of 10 rupees per month to 500 rupees per month. If re-engaged, 550 rupees per month rising to 650 rupees per month. Overtime pay on certain conditions. Free quarters, medical attendance and second-class passage out and home for selected Candidate, wife and family.

Further particulars and forms of application can be obtained from the DIRECTOR GENERAL OF STORES, India Office, Whitehall. F 620

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

APPOINTMENT OF BOILER-HOUSE SHIFT ENGINEER.

Applications are Invited for

the POSITION of SHIFT ENGINEER to take charge of the running of the Boiler-house at the Summer Lane Generating Station.

Applicants must have had a sound mechanical and engineering training, and must have had previous charge of fairly large installations of high pressure steam boilers fed with mechanical stokers.

The salary offered is £150 per annum, plus £10 extra per annum during the war.

Applications (made on forms which can be obtained from the Secretary of the Electric Supply Department) accompanied by not more than three testimonials as to experience, ability, and character, must reach the undersigned not later than Wednesday, December 13th, 1916.

R. A. CHATTOCK,
City Electrical Engineer.
Electrical Supply Department,
14, Dale End, Birmingham,
20th November, 1916. F 597

Wanted for Abroad, Competent

MAN accustomed to handling heavy wire ropes and splicing same; must be over military age or ineligible. Free board, quarters, and passage provided.—Address applications, with copies of testimonials, to "ZERIMA," care of STREETS, 30, Cornhill, E.C. F 603

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factory, Stockport district, TOOL ROOM FOREMAN. One with all-round experience preferred. State age, wages expected, and when at liberty. No one engaged on Government work will be employed.—Apply, your nearest LABOUR EMPLOYMENT EXCHANGE, mentioning this Journal and F 598.

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Capable Works Manager (41),

DISENGAGED. Efficient knowledge of modern methods of production, labour-saving machine tools, repetition and Government work. Organiser and control of mixed labour; strict disciplinarian.—Address, F 614, Offices of ENGINEERING.

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QUIRES permanent POSITION; experience in manufacture, erection, and running all kinds of machinery at home and abroad, also patents.—Address, F 624, Offices of ENGINEERING.

Mechanical Engineer, hold-

ing chief engineer's Board of Trade Certificate, practical all-round experience, OPEN to APPOINTMENT as Works Engineer or Manager.—Address, F 615, Offices of ENGINEERING.

Aerial Ropeways.—Qualified

Mechanical Engineer (42), Open organize London Office for good firm desirous striking this important direction.—Address, F 623, Offices of ENGINEERING.

Wanted, by an Experienced

railroad man, who for the last 10 years has had charge of loco. running shed repairs, also erection; has no objection to going abroad; good references; age 49; or would take a position as Loco. or Stationary Engine Driver.—Address, F 611, Offices of ENGINEERING.

Foreman Smith Requires Post,

experienced in forgings, marine and general; used to drawings and control of men. Good references.—Address, F 584, Offices of ENGINEERING.

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Jensen and Son, 5576

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THE WILLANS LINE FOR STEAM TURBINES.

WITH throttle-governed steam turbines Willans' law that the total steam consumption plotted against output is nearly a straight line is followed with very considerable accuracy. In the accompanying diagram, for example, we have drawn the Willans line for the 5,000-kw. Rateau turbine at the L.C.C. power station, the data being taken from the paper read by Mr. K. Baumann before the Institution of Electrical Engineers in 1911. This paper, we may add, is notable not merely for its exhaustive treatment of many important problems in turbine design, but for the valuable collection of test data of turbines of all types, accessible elsewhere only in scattered papers and communications.

In this figure the output in brake kilowatts has been plotted, and not the power developed at the switchboard. The four points plotted in the diagram lie, it will be seen, very fairly in a straight line which, if prolonged, cuts the horizontal axis at B. It has frequently been assumed that the distance O B, measured on the kilowatts scale, represents the power required to drive the turbine light, and that the slope of the line B A is proportional to the blading efficiency of the turbine. Neither of these propositions is correct, but some very interesting deductions can, nevertheless, be made from a study of the Willans line of a turbine.

A turbine differs from a reciprocating engine in that by far the larger proportion of its wastes of energy, which are due mainly to windage, leakage losses, and fluid friction, are proportional to the load. The resistances and losses which are independent of the load are merely those due to the bearings and thrust block, the oil pump and governor drive, and to the glands. If water-packed glands are used, as in the case of the L.C.C. turbine in question, the gland losses are represented by the power absorbed by these glands, whilst if steam-packed glands are used the loss is represented by the supply of steam necessary to prevent the entrance of air through the glands into the condenser. Each gland is, in fact, connected up permanently to a live steam supply, which is wire-drawn at the gland to a pressure such that there is a small steady leak of steam from the gland to the outer air, whilst a larger proportion of the supply leaks through the labyrinth to the condenser.

Each of these constant losses can be calculated with fair accuracy. The power absorbed in a turbine bearing in ordinary running conditions is, for example, given by the relation :—

Power absorbed in bearing, d inches in diameter and l inches long,

$$= \frac{1}{3}\left(\frac{d}{10}\right)^2 \left(\frac{l}{10}\right) \frac{\text{R.P.M.}}{100} \text{ in H.P.}$$

$$= \frac{1}{4}\left(\frac{d}{10}\right)^2 \left(\frac{l}{10}\right) \frac{\text{R.P.M.}}{100} \text{ in kw.}$$

$$= 850\left(\frac{d}{10}\right)^2 \frac{l}{10} \cdot \frac{\text{R.P.M.}}{100} \text{ in B.Th.U. per hour.}$$

The above coefficients, it will be seen, are rounded-off numbers, since 3 kw. is not exactly 4 h.p.

The L.C.C. turbine has main bearings 12 in. in diameter by 38 in. long, and runs at 750 r.p.m., so that the power absorbed by one bearing is 13.7 h.p.

The thrust bearing has 12 collars 1 in. deep and 10 in. in mean diameter. The resistance of such a thrust block is approximately ½ lb. for each square inch of oil under load, so that the power absorbed by the thrust block is in round figures given by the relation :—

$$\text{Power absorbed} = \frac{N b}{8} \cdot \left(\frac{d}{10}\right)^2 \cdot \frac{\text{R.P.M.}}{100} \text{ H.P.,}$$

where N denotes the number of collars, b their breadth in inches, and d the mean diameter in inches of the collars.

For the L.C.C. turbine this formula gives 11.3 h.p. as the power absorbed. If we increase this to 16 h.p. the power absorbed by the oil pump and governor drive will be sufficiently allowed for.

The experiments of Gibson and Ryan on the friction of rotating discs (Min. Proc. Inst. C.E., vol. clxxix) make possible a fair estimate of the power absorbed by the water glands. From these experiments we find that the power absorbed by a smooth thin disc of diameter d in., rotating in water, is given by the relation :—

$$\text{Friction H.P.} = \frac{1}{5000} \cdot \left(\frac{d}{10}\right)^2 \left[\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100}\right]^{2\cdot6}$$

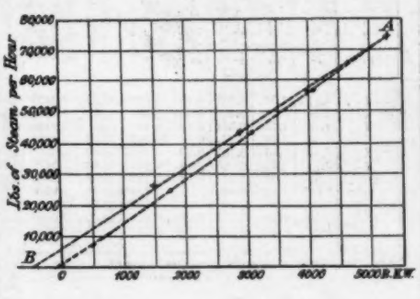
The addition of ribs to the disc increased this in a ratio of say 4.5 to 1.

From the above, and noting that a disc has two sides, we further deduce that the frictional resistance of a cylinder of diameter d and length l is expressed by

$$\text{Friction H.P.} = \frac{1}{2100} \cdot \frac{d}{10} \cdot \frac{l}{10} \left[\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100}\right]^{2\cdot6}$$

The fans of the water glands of the L.C.C. turbine are 28 in. in external diameter and 2 in. wide at the periphery. Assuming that when the turbine is at work the free face of the water has a diameter of 19 in. on one side and 26 in. on the other, the power absorbed by each gland amounts to 21.8 h.p. Adding together all these resistances, we get a total of 89 h.p., or, say, 66 kw., which is only about one-sixth of the distance represented by O B in the diagram, which scales 450 kw.

This wide discrepancy is due to the fact that the Willans line, A B, is not a line of constant indicated efficiency. The indicated efficiency of a turbine varies with the ratio of expansion. In many cases, particularly with reaction turbines, which for commercial reasons have hitherto been run much



below their most economical speed, the indicated efficiency at first increases as the load is reduced, afterwards diminishing again somewhat rapidly. It is, however, possible, to a fair degree of accuracy, to deduce from the actual Willans line the Willans line corresponding to a constant indicated efficiency by making use of the proposition, which is very approximately true, that when a turbine is throttle-governed the indicated efficiency depends solely on the ratio of initial to final pressure.

With a perfect gas this proposition is necessarily true, since the volume passing through each stage of a turbine, taking its supply, of such a gas, at 200 lb. absolute and expanding it down to 1 lb., would be exactly the same at each point as when the initial pressure is first wire-drawn through the governor valve down to 100 lb. and then expanded through the turbine down to ½ lb. per square inch. The relative velocity of the gas relatively to the guide blades and buckets being the same at all points, the efficiencies will be the same. On the other hand, the output in the two conditions will be halved, as exactly half the weight will enter the turbine. Steam is not a perfect gas, but the rule holds, nevertheless, with considerable accuracy throughout a large range of output.

The data from which the diagram was plotted are as follow :—

Output of Turbine. B.kw.	Total Steam per hour. Lb.	Ratio of Initial to Final Pressure.
5,347	73,930	228
4,000	56,070	185
2,885	42,630	123
1,449	25,070	74

Of the total resistances of the turbine those due to fan action, leakage and the like are substantially proportional to the load. The fixed resistances have been estimated above as 66 kw., so that the gross output corresponding to the total torque developed at full load will be 5,347 + 66 = 5,413 kw. Calling this the gross kilowatts, the steam consumption per gross kilowatt is 13.66 lb. By the foregoing rule the consumption per gross kilowatt will be the same at all powers, provided the ratio of the initial and final pressures is the same. At the lowest load tabulated above the initial pressure was 56 lb. absolute and the back pressure 1.55 in. of mercury. To get the same gross efficiency this back pressure should have been approximately $\frac{74}{228}$ 1.55 = 0.68 in. of mercury, and in that case the output would have been $\frac{25{,}070}{13.66}$ = 1,836 gross kilowatts, or 1,836 − 66 = 1,770 b.kw.

This value has been plotted as a round dot in the diagram, and the other observations have been similarly reduced. The corrected Willans line thus obtained cuts the axis at a point scaling about 70 kw., and thus passes very approximately through the estimated value of the bearing, gland, and other fixed losses.

Whilst the Willans line corrected as above is no doubt approximately correct, it should be noted that the superheat was relatively higher at the lower loads and would be retained for a larger proportion of the total expansion. A correction should no doubt be made for this, but the existing data as to superheat corrections are hardly sufficiently reliable to make this feasible.

To sum up, with the Willans line as ordinarily plotted the heat available per pound of steam passed falls off as the load diminishes. Hence less work is done per pound of steam, and the line at low loads is raised correspondingly.

The Willans line adjusted as above can be used to estimate approximately the increase in consumption at full load due to a reduction in the vacuum. In the test made at 2,885 b.kw. the gross output was 2,885 + 66 = 2,951 kw. and the steam consumption per gross kilowatt-hour was therefore 14.45 lb., the ratio of expansion being 123. At full load the steam pressure below the governor valve was 166.5 lb. absolute and the back pressure 1.49 in. of mercury, giving a ratio of expansion of 228. With a ratio of expansion of 123 the back pressure would be $\frac{1.49 \times 228}{123}$ = 2.77 in. of mercury, and the consumption per gross kilowatt-hour would then be approximately the same as at half-load, or 14.45 lb. Hence a diminution of vacuum from 28.51 to 27.23 in. would reduce the gross output from 5,413 to about 5,100 gross kw., or to 5,034 b.kw. Hence such a decrease of vacuum would increase the steam consumption per b.kw.-hour by about 6 per cent.

THE TORSION OF SOLID AND HOLLOW PRISMS AND CYLINDERS.

By CYRIL BATHO, M.Sc., B.Eng., Assistant Professor of Applied Mechanics, McGill University, Montreal, Canada.

(*Concluded from page* 498.)

§5. *The Rectangular Shaft. Approximate Solutions.*—One of the most important cases is that of the rectangular shaft. Unfortunately the analysis in this case is complicated. The problem was first solved by St. Venant and has since been somewhat simplified by Goetzke.* Bach has shown that St. Venant's value for the maximum stress is given very approximately by the formula

$$q_{max.} = \left(3 + \frac{2 \cdot 6}{0.45 + \frac{h}{b}}\right) \frac{T}{b^2 h} = \phi \cdot \frac{T}{b^3 h} \quad (20)$$

where b is the length of the shorter side and h that of the longer side. Bretschneider has verified this result experimentally.† Approximate solutions have been given by Bach and others leading to the formula

$$q_{max.} = 4 \cdot 5 \frac{T}{b^2 h} \quad . \quad . \quad . \quad (21)$$

which is often used in practice for all ratios of b to h, although very far from the truth if h is much greater than b.

This formula may be obtained by the method of §3 and §4 by assuming

$$= \left(x^2 - \frac{b^2}{4}\right)\left(y^2 - \frac{h^2}{4}\right).$$

This is the simplest function which satisfies the boundary conditions, but is not correct, since it

* Zeitschrift des Vereines Deutscher Ingenieure, 1909, page 935.

† Bach, Elasticität und Festigkeit, 6th edition, page 342.

does not satisfy equation (10), and so can only give an approximate solution. Proceeding as in §4, the maximum stress will be that given by equation (21) and the stress at the corners will be found to be zero. The distribution of stress throughout agrees with that assumed by Bach.

A very approximate solution may be obtained simply if the ratio h/b is large,. In this case the lines of shear, except at the ends, must be parallel to the longer side, *i.e.*, $q_x = 0$ if the axis of y is parallel to the longer side. Thus equation (10) reduces to

$$\frac{\partial^2 f}{\partial x^2} = 2c$$

where c is a constant. Integrating this,

$$f = c x^2 + d,$$

where d is also a constant, q_y being equal to zero when $x = 0$. Thus the lines of shear, neglecting the effect of the ends, are given by

$$c x^2 + d = \lambda.$$

At the boundary,

$$x = \frac{b}{2}, \lambda = 0$$

and thus

$$f = c\left(x^2 - \frac{b^2}{4}\right).$$

This leads to

$$\mathrm{K}\, c = \frac{3\,\mathrm{T}}{h\, b^3}.$$

Thus

$$q_y = \frac{3\,\mathrm{T}}{\mathrm{A}\, t} \quad . \quad . \quad . \quad . \quad (22)$$

and is constant over the longer sides.

This agrees with St. Venant's result if $\frac{h}{b} = \infty$

6. *Structural Steel* I, C, L *and* T *Sections.*—The result obtained for a thin rectangular section will be very approximately true for a thin section of any shape, as, for example, an ordinary angle section, provided that, as is usually the case in practice, the inner corners are rounded to prevent concentrations of stress near to them. This may be seen at once from the fact that the lines of shear in such a section must be parallel to the contour all over the section except in the immediate neighbourhood of the ends or corners. Thus for any of the rolled sections used in practice

$$q_{max.} = \phi \frac{\mathrm{T}}{\mathrm{A}\, t} \quad . \quad . \quad . \quad (23)$$

where ϕ is a constant which will not differ greatly from 3.

The angle of twist is given by

$$\theta = \frac{l}{\mathrm{T\,G}} \int q^2 . d\, a,$$

as in the cases considered above. At any point distant x from the centre line of the section,

$$q = \phi \cdot \frac{\mathrm{T}}{\mathrm{A}\, t} \cdot \frac{2x}{t}.$$

Thus

$$\theta = \frac{\phi^2\, \mathrm{T}\, l}{3\,\mathrm{G\,A}\, t^2} \quad . \quad . \quad . \quad (24).$$

The above assumes that the thickness of the section is the same throughout. In I, channel and tee sections the thickness of the flanges is usually greater than the thickness of the web. Equation (23) is true for these if t be the least thickness, but in calculating θ it is necessary to take account of the difference in stress distribution in the web and flanges. If t_2 be the thickness of the flanges and t_1 of the web, the maximum stress in the flanges will be

$$\frac{t_1}{t_2} \cdot q_{max.}$$

Thus, making the same assumptions as before,

$$\theta = \frac{\phi^2\, \mathrm{T}\, l}{3\,\mathrm{G}\, \mathrm{A}^2\, t_1^2}\left[\mathrm{A}_1 + \frac{t_1^2}{t_2^2}\mathrm{A}_2\right] . \quad . \quad (25)$$

where A_1 is the area of the web, A_2 the total flange area, and $\mathrm{A} = \mathrm{A}_1 + \mathrm{A}_2$. If the web is thicker than the flanges, A_1 and A_2 and t_1 and t_2 must be interchanged.

The above may be extended to cases in which the flanges are of different thicknesses, &c., by adding terms similar to the last term in the bracket.

ϕ may be determined experimentally for any given section by measuring the angle of twist θ for a given twisting moment T. Mr. Ritchie, in the paper referred to above, reports such measurements on a series of I, T, C and L sections. Table II gives the results of the tests and the values of ϕ calculated from them by using formula (25). It will be noticed that all the sections are stiffer than would be expected from the above theory, *i.e.*, ϕ is less than 3. For the channel it is only about 3 per cent. and for the angles 8.2 per cent. less than 3. For the T it is about 9.7 per cent., whilst for the I sections the results are very variable, the average being 19 per cent. lower than 3.

Thus the above theory seems to hold fairly well for channel and angle sections, but gives results much too high for I and T sections. This may be due partly to the conditions of stress at those portions of the flanges just above the junction with the web in the latter sections. A more complete series of tests on larger specimens, carefully graded as to relative width of flange, relative thickness of webs and flanges, &c., would probably throw more light on this and perhaps lead to a more complete theory or at least to an empirical formula for these cases. In the meantime equations (23) and (25) may be considered as giving results a little higher than the actual stress and angle of twist respectively.

Table II.

No.	Type of Section.	Dimensions in Inches. Width.	Depth.	Thickness of Flange.	Thickness of Web.	Area. (Sq. In.)	G ÷ 10^6 in Lb. per Sq. In.	Angle of Twist in Deg. over 5 ft. Span, for 50 In.-Lb. Torque.	ϕ.
1	I	5.01	8.02	0.605	0.30	8.02	11.43	0.0137	2.13
2	I	3.01	3.00	0.325	0.20	2.43	—	0.1445	2.38
3	I	1.75	4.78	0.324	0.19	1.91	—	0.2460	2.35
4	I	1.66	3.16	0.230	0.17	1.222	11.32	0.6450	2.50
5	I	0.99	1.95	0.165	0.22	0.6825	11.30	1.6210	2.76
6	I	0.76	1.50	0.165	0.14	0.4141	11.68	2.9470	2.42
7	Channel	0.97	2.00	0.227	0.22	0.7825	11.61	1.0650	2.91
8	Angle	1.175	1.175	0.250	—	0.5245	10.95	1.2260	2.76
9	Angle	1.00	1.00	0.185	—	0.3363	11.00	3.4300	2.76
10	Tee	1.58	1.58	0.231	0.21	0.650	11.50	1.0080	2.54
11	Tee	0.99	0.99	0.135	0.145	0.3573	11.41	8.3850	2.89

N.B.—Mr. Ritchie does not give the value of G for specimens 1 to 3. The value given here is the mean of those for specimens 4 to 6.

7. *Hollow Sections.*—Both the inner and outer boundaries of the cross-sections of a hollow shaft must be lines of shear. Thus the function f must vanish at the outer boundary and be equal to a constant at the inner boundary. The equation,

$$\mathrm{T} = 2\,\mathrm{K} \int a\, . d\, f,$$

will be true, but the integration will extend only from the inner boundary to the outer. Thus, integrating by parts,

$$\mathrm{T} = 2\,\mathrm{K}\,[a\, f] - 2\,\mathrm{K} \int f\, d\, a.$$

The product $a\, f$ vanishes at the outer boundary since $f = 0$, but is equal to a_1 at the inner boundary, λ_1, being the value of the parameter λ which gives the equation of the inner boundary and a_1 the area of the hollow.

Thus

$$\mathrm{T} = 2\,\mathrm{K}\left\{a_1 \lambda_1 - \int f\, .\, d\, a\right\} \quad . \quad . \quad (26)$$

the integration extending from the inner to the outer boundary.

As an example of the method, a hollow elliptical cylinder bounded by two similar ellipses will be considered. Since the lines of shear of a solid elliptical shaft are similar ellipses to the boundary, the function f will be the same as in example *a* § 4, *i.e.*,

$$f = \frac{x^2}{b^2} + \frac{y^2}{h^2} - 1 = \lambda,$$

b and h being the semi-axes of the outer boundary.

Let the semi-axes of the inner boundary be $\gamma\, b$ and $\gamma\, h$ respectively. Then the equation of the inner boundary will be

$$\frac{x^2}{b^2} + \frac{y^2}{h^2} - 1 = \gamma^2 - 1.$$

Thus

$$a_1 = \pi\, \gamma^2\, b\, h$$
$$\lambda_1 = \gamma^2 - 1$$

and

$$\frac{\mathrm{T}}{2\,\mathrm{K}} = \gamma^2 (\gamma^2 - 1)\, \pi\, b\, h - \int\left(\frac{x^2}{b^2} + \frac{y^2}{h^2} - 1\right) d\, a.$$

This leads to

$$\mathrm{K} = \frac{\mathrm{T}}{(1 - \gamma^4)\, \pi\, b\, h}.$$

Thus the maximum stress occurs, as in the case of the solid section, at the end of the minor axis and

$$q_{max.} = \frac{2\,\mathrm{T}}{\pi\, b\, h^2\,(1 - \gamma^4)} \quad . \quad . \quad (27).$$

This formula is often given in engineering text-books as applying to any hollow elliptical cylinder, but is, of course, true *only when the inner boundary is a similar ellipse to the outer.* No matter how thin the walls of the cylinder may be, this will not give a section having uniform thickness of walls, and so the formula cannot be applied to an ordinary elliptical tube. This was pointed out by the writer in a recent letter (Engineering, March 31, 1916, page 298) in which it was shown that, for an elliptical tube of uniform thickness equal to $\frac{1}{100}$ of the semi-minor axis, the ratio of the axes being 3 to 1, the correct value of the maximum stress is about 21.2 per cent. lower than that given by equation (27).

In most hollow shafts which are used in practice the inner boundary is of the same shape as the outer, *i.e.*, the walls are of uniform thickness, and thus the inner contour is not, in general, a line of shear for the solid section. Thus f will not usually have the same form as in the solid shaft of the same shape and its determination becomes difficult. This is so, for example, in either a hollow triangular or hollow rectangular shaft of uniform thickness. The formula usually given for the latter is

$$q_{max.} = \phi \cdot \frac{\mathrm{T}\, b}{b^3\, h - b_0^3\, h_0},$$

where b_0 and h_0 are the sides of the inner boundary, the other symbols having the same meaning as in equation (20). This seems to have been arrived at, by analogy, from the formula for a hollow circular shaft :—

$$q_{max.} = \frac{\mathrm{T}\, r}{\mathrm{J} - \mathrm{J}_0},$$

where r is the external radius and J and J_0 the polar moments of inertia for circles of radii equal respectively to the outer and inner radius of the section. It thus appears to be based upon two assumptions :—(1) that the shear stress varies as the distance from the centroid to the mid-point of the longer side; (2) that $b^3 h - b_0^3 h_0$ may be regarded as an equivalent J for the section. It has been shown by St. Venant that assumption (1) is incorrect. Assumption (2) is equivalent to stating that the inner rectangle is a line of shear for a solid rectangular shaft having the same boundary as the hollow shaft and that the lines of shear are the same as in the solid shaft. It is thus incorrect even when the walls are thin. An actual line of shear just within the contour of a solid rectangular shaft is a continuous curve practically parallel to the boundary near the centres of the sides but curving inwards quickly as it approaches the corners, somewhat as the line of shear for the triangular shaft shown in Fig. 2, page 498 *ante*. Thus the formula cannot be expected to give correct results. In the letter already mentioned it was shown that for a thin hollow rectangular shaft having walls of thickness equal to $\frac{1}{200}$ of b, the error is probably about 21 per cent.

No satisfactory formulæ have, as far as the writer is aware, been given for thick-walled hollow shafts of the sections, other than circular, ordinarily used in practice. If the walls are thin or even of moderate thickness, the method of §2 may be used with some confidence.

In conclusion, the writer wishes to thank Professor E. Brown for his valuable suggestions and for checking the numerical work.

THE ARRANGEMENT OF MACHINE SHOPS.—No. VII.

By Joseph Horner.

The machine shops at the works of Messrs. John Samuel White and Co., Limited, of East Cowes, Isle of Wight, which we illustrate in connection with this article, possess a special interest because the firm has a high reputation all over the world as shipbuilders and marine engineers. These shops illustrate very completely in their sharply-defined arrangements the line and countershaft methods of driving adopted for the smaller machine tools, and the individual motor driving employed for the

heavy ones. The saw-tooth roof is utilised for the light machinery shops, the ridge roof for the heavy shop. The details of the lay-out of the shops are shown very fully in our illustrations on the present page, on page 524, and on Plate XLIV, these views affording an instructive study in the provisions made for carrying through marine engineering work.

The shops all occupy ground-floor areas. To the east of the light machine shop A, of which a plan is given in Fig. 38, subjoined, the heavy machine shop E (Fig. 49, Plate XLIV) is located. The shops C and D lie south of E. We may commence with shop A, shown in its plan arrangements by Fig. 38, and in sectional elevation looking from the large machine shop E, in Fig. 39. The saw-tooth roof shown in this figure is carried on columns of individual machines are outlined in the plan with sufficient clearness to indicate their character. The locations of the three motors which drive the line shafting, and are seen in plan, include two of 30 brake horse-power and one of 55 brake horse-power. The whole of the machines in this shop are belt-driven from these lines of shafting. As will be seen, the shop is not crowded and congested, in fact there are considerable areas available for the future installation of new machines as required. There are also very broad clear passages for trolleys and the stacking of work in progress. The floor is of wood on concrete. The entire area covered by the roofs is unobstructed. A tool room extending along the south side has windows opening into it from the machine shop, therefore, equipped with machines of a character suited specially to these services. The plan and elevations, Figs. 40 to 46, show the machines in outline, and the scheme of driving them from shafting, which is motor-driven. As seen in the plan view, Fig. 40, the machine shops C and D occupy one building. C is the large machine shop, D is the shafting and condenser shop, the two running parallel and separated only by the columns of rolled joists which carry the roof principals and the runways of the overhead travelling cranes. Fig. 41 is a view taken at the west end, looking eastward, Fig. 43 is from the east end, looking west. Fig. 44 is a transverse section at C—D on Fig. 40, looking west. Fig. 45 is a zigzag section at A—B, on Fig. 40, looking north, and Fig. 46 an elevation of the shafting taken at the west end of Fig. 40. By a comparison of these views the general design and the detailed arrangements will be understood without much difficulty. The view Fig. 47, Plate XLIII, is taken in the D shop, being the shafting and condenser department of Fig. 40, and Fig. 48 in the C shop. The two run parallel without any separation, except that of the columns that support the roof and the crane runways. In these shops both belt driving and individual motor driving are adopted. The line shafts, 3 in. and 2¼ in. diameter, are driven by motors at 180 r.p.m. The countershaft speeds belted from these range over large differences to suit the extensive range of machine speeds.

There are two lines of main shafting, one having its bearings attached to the columns on the north side of the C shop (Fig. 47), the other to the columns which form the boundary between the large machine shop C (Fig. 46) and the shafting and condenser shop D. The first is driven by a motor of 30 brake horse-power, making 540 r.p.m., the second by one of 64 brake horse-power running at 650 r.p.m. The general scheme of the connections between the line and countershafts is seen by comparing the end views and elevations (Figs. 41 to 46) with the plan (Fig. 40). The shops are lofty enough to permit of the countershafts being driven either by vertical belts or by belting at a moderate angle. The bearings are located at various heights between the line shaft and the machines that are driven from the countershafts. The bearing brackets are generally attached to light stretcher girders that connect the main columns, along which girders the brackets can be adjusted. The line and countershaft arrangements are seen very well in the photograph (Fig. 47).

Fig. 38. MACHINE SHOP "A".

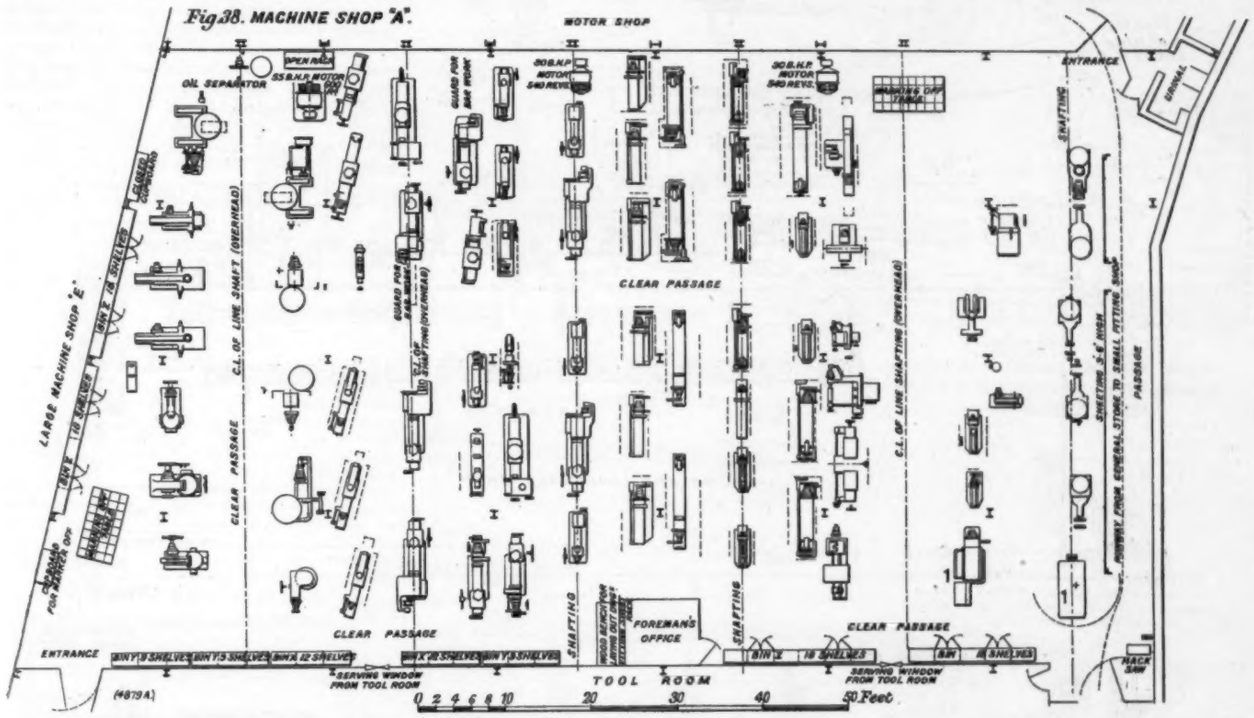
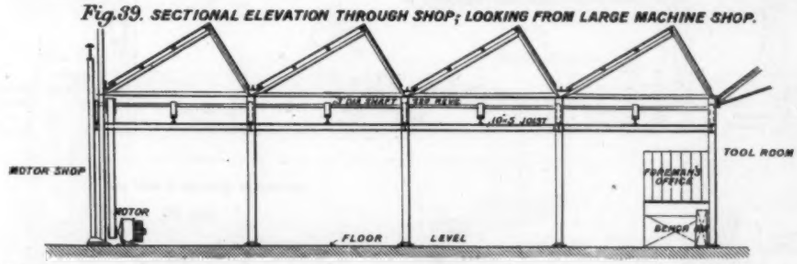


Fig. 39. SECTIONAL ELEVATION THROUGH SHOP; LOOKING FROM LARGE MACHINE SHOP.



FIGS. 38 AND 39. MACHINE SHOP; MESSRS. J. SAMUEL WHITE AND CO., LTD., EAST COWES.

H-section, seen in the plan view (Fig. 38). The glazing occupies the whole of the north slope, the other slope is covered with corrugated sheeting. The shafting bearings are carried on rolled joists.

The lines of overhead shafting, 3 in. in diameter, six in number, are motor-driven from the floor, and run at 220 r.p.m. Their locations in plan are indicated by the dot-and-dash lines in Fig. 38. Their bearings are self-aligning, with Tilston forced lubrication. It will be observed that the shafts are disposed across the bays, and that the machines are arranged similarly, instead of, as is usual, parallel with the roofs. This is obviously an ideal arrangement in regard to lighting, the north light coming full over the longitudinal direction of the machines instead of in an endwise direction.

The lathes in this shop—screw-cutting, capstan and turret—outnumber the other groups of machine tools, which comprise drilling, boring, slotting, shaping, and milling machines. The various through which the tools are handed in and out. Along the same side of the shop, storage bins and shelves are ranged, and similar conveniences are placed along the eastern wall where the large machine shop E joins it. To avoid fire, all bins, racks, tool boxes and foremen's offices are of steel. Two marking-off tables testify to the individual character of some sections of the work done. An oil separator supplements the products of turret and capstan lathes. A motor-fitting shop on the north side is connected with the general store by a runway in a passage which is divided off from the main machine shop by a fence of corrugated sheeting, 3 ft. 6 in. high.

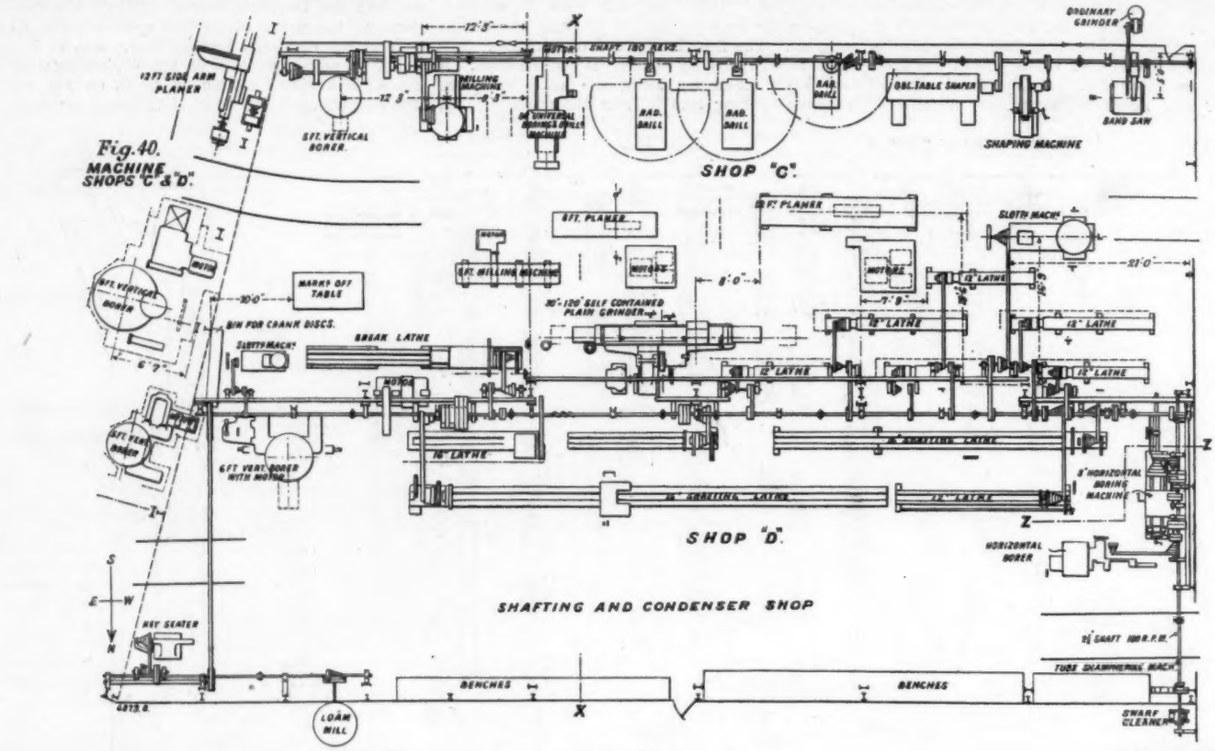
The machine shops C and D, illustrated by the plan and sections, Figs. 40 to 46, on page 524, and the photographs reproduced in Figs. 47 and 48, on Plate XLIII, are devoted to the tooling of shafts for turbines, propellers and other services, and to the manufacture of condenser parts. They are,

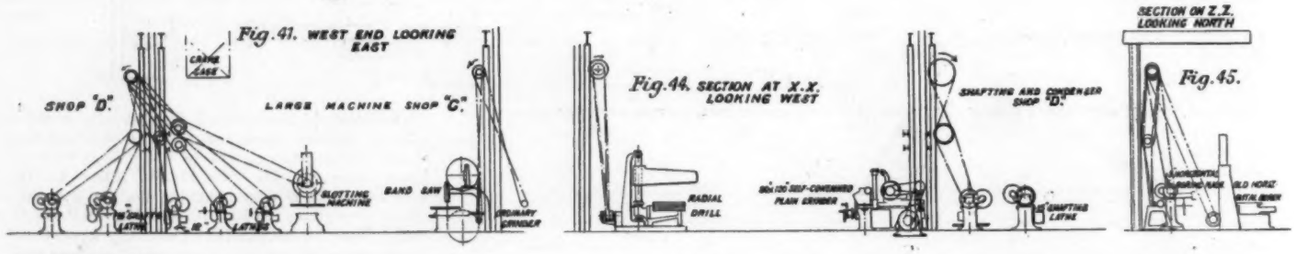
The line shaft bearings are carried on hanger brackets which are bolted up to the undersides of the joists which carry the crane runways (Figs. 47 and 48). The machines are arranged in parallel (compare Figs 40 to 48) and on opposite sides of the line shaft. Generally the heavier machines are so placed as to be provided with the longer belt drives. At the western end of the shafting and condenser shop a short length of 2½-in. shafting is driven by a quarter twist belt to serve boring machines situated there (compare Figs. 40 and 42).

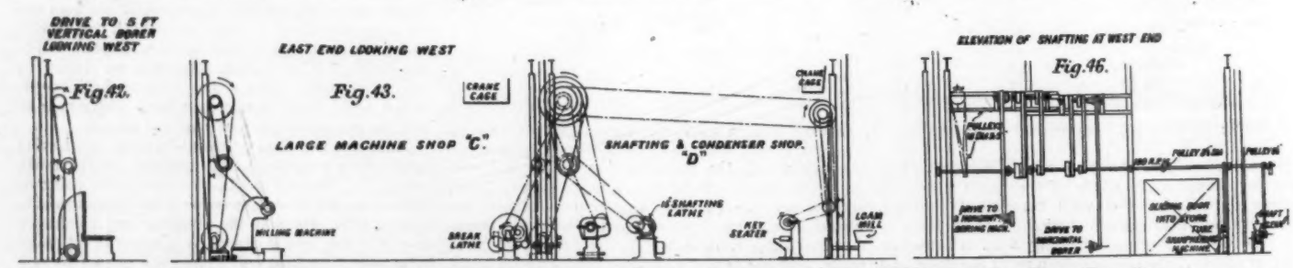
In the large machine shop C (Figs. 40 and 48) three machines have individual motor drives—two planers and a milling machine. At the east end also two vertical boring machines are motor-driven. The principal machines in the shafting and condenser shop (Figs. 40 and 47) are lathes. A 15-in. shafting lathe has a bed of about 50 ft. in length. If anything longer has to be turned, a 12-in. lathe, set in alignment with it, is utilised to support the poppet. Benches are arranged along the outer wall of the shafting and condenser shop. A central area is left clear for fitting and erecting, and is served by a travelling crane.

The heavy machine shop E is shown in plan by Fig. 49, Plate XLIV, with cross-sections through the planes A—B, C—D, and E—F respectively in Figs. 50, 51 and 53, and photographs in Figs. 54 and 55. The ridge roof is carried on columns of rolled joists. The areas are covered with three electric overhead travellers of 12, 30 and 25 tons capacity respectively. In addition, some of the machines are served by light radial jib cranes of 30-cwt. capacity for making adjustments of work. This is a shop the equipment of which is specialised to handle one class of heavy product.

There are not many machines here, but they are all of a massive character, to deal with the larger parts of steam turbines, rotors and casings, and large areas are left for erection. These machines form an interesting study in individual motor drives. Beginning at the right-hand end of Fig. 49, a very fine turbine-boring machine occupies the east side of the shop. Its movements are derived from two motors, of 28 brake horse-power and 30 brake horse-power, one being located at each end, whence the speeds and feeds are changed by belts on stepped cones. It is served by two 30-cwt. swing-jib hand cranes. Parallel with this is a wide turbine-planing machine of 25-ft. stroke, with a travelling tool cross-rail which is actuated by two screws driven by a 30 brake horse-power motor at the rear. In line with this is a lathe of 48-in. centres of special design for sliding, surfacing and boring. This also is driven by one motor, of 50 brake horse-power, with its speeds and feeds belt-regulated on stepped cones. Here a rail track crosses the shop, connecting the motor-erecting shop with the test shop. Then comes another large turbine-boring machine, with a 31 brake horse-power motor, and a vertical boring mill served by a 12 brake horse-power motor. On the other side of the gangway there is a 6-ft. radial drilling machine equipped with a 15 brake horse-power motor, and two 5 ft. 6 in. horizontal boring machines actuated by belts from two countershafts driven by one 10 brake horse-power motor. A rail







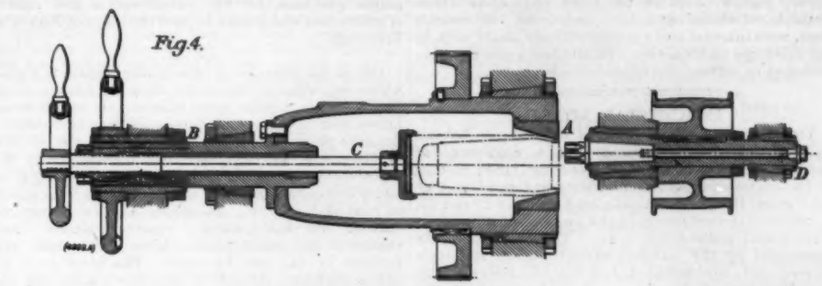
FIGS. 40 TO 46. TURBINE AND PROPELLER SHAFT MACHINE SHOPS; MESSRS. J. SAMUEL WHITE AND CO., LTD., EAST COWES.

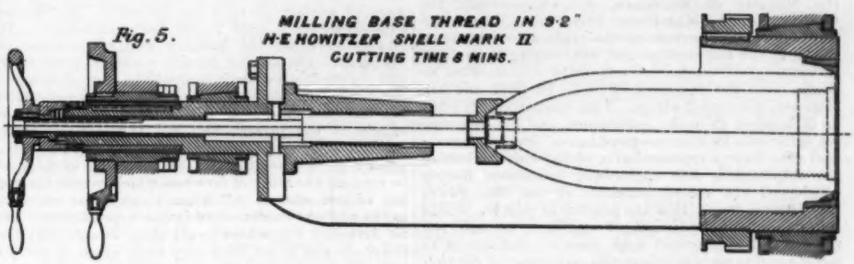
track into the condenser shop intervenes between these and a boring machine with a 10 brake horse-power motor and countershaft, and two drilling machines, belt-driven from a countershaft actuated from the boiler shop drilling bay. The next machine is a 16-ft. vertical boring and turning mill, which has its movements derived from a 30 brake horse-power motor through gears. Then there is a rail track to the boiler shop, and on the other side of it a 7-ft. radial drilling and tapping machine with its 10 brake horse-power motor drive. On the opposite side of the gangway is a 12-ft. side arm planing machine with Lancashire drive, from a 16½ brake horse-power motor.

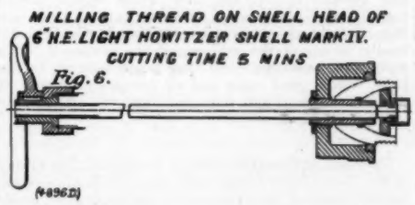
A rail track extends to the machine shop C and there are two vertical boring mills, 8 ft. and 5 ft., each with its motor, of 20 and 10 brake horse-power respectively. Flanking the other side of the gangway is a large radial drill, with travelling standard, for drilling large turbines, driven by a motor of 15 brake horse-power, and there is also a 36-in. centres sliding, surfacing and boring lathe with a 25 brake horse-power motor and countershaft drive. Finally, there are a marking-off table, and a 16-ft. vertical boring and turning mill, with a 42 brake horse-power motor. Here the shop terminates with rail tracks connecting it to the machine shop D and to the foundry. These shops have ridge roofs with continuous skylights on both slopes. Incandescent oil lamps at the sides, out of the way of the travelling cranes, provide for illumination, and electric lamps of filament type are used only as portable lighting media.

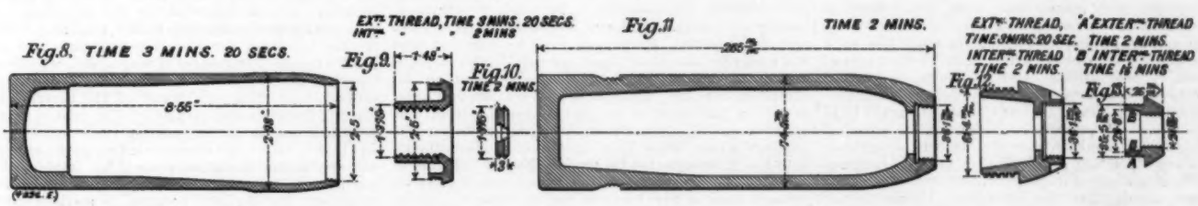
MILLING SCREW THREADS.

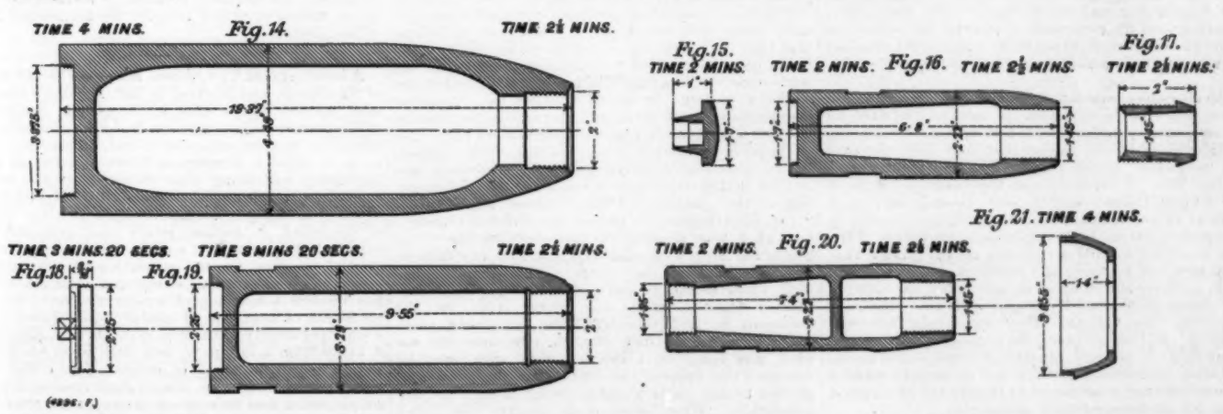
FOR many years a method of producing comparatively short screw threads by milling, using a cutter the full length of the thread and completing the latter in one revolution of the work, has been in use in small arms factories. Messrs. J. Archdale and Co., Limited, of Birmingham, have made a special study of this system of thread cutting, and they manufacture machines which, before the war, were used to some extent in shell and fuze factories, and in addition by











the motor and other civil industries where large quantities of work were produced.

Compared with ordinary chasing or screw cutting in the lathe the process of milling threads is much more speedy and reduces labour cost, whilst compared with screwing by taps or dies it has the great advantage that every part of the whole length of the cutter used is equally engaged in producing the thread, whereas in the case of the tap or die the leading end only does the work.

In the case of internal or external threads that are close to a shoulder through or over which the tap or die cannot pass, the advantages of this method are still more pronounced and recognised, consequently since the war began the use of this process of producing threads has grown to an enormous extent in connection with the manufacture of munitions, and Messrs. Archdale have supplied several hundreds of their thread-milling machines to factories engaged on such work.

The firm manufacture four sizes of machines suitable for dealing with shells. On Plate XLV, published this week, Fig. 1 illustrates the smallest of these machines, taking up to 18-pr. shell bodies, and represents also the design of the next larger size, for shell bodies up to 4.5 in. diameter. Fig. 2 shows specimens of threads milled on various motor and cycle parts done on the machine illustrated by Fig. 1. Fig. 3 illustrates the largest machine, for shell bodies up to 9.2 in. diameter, and also represents the design of the 6-in. shell machine.

Fig. 4, on the present page, is a detail showing a self-centring chuck or special work-holder, A, which is rotated by a cone pulley through bevel gearing and worm gearing, the cone pulley being driven from a countershaft. The pitch of the thread cut is determined by a short detachable guide screw B keyed on to the tail end of the work spindle. The guide screw engages a nut (also detachable) which is carried by the bracket at the tail of the headstock. On rotation the work spindle C is made to move longitudinally in its bearings by means of the guide screw and nut.

The cutter spindle D is driven separately from a countershaft. The cutter headstock is adjustable transversely by a screw, a dead stop being provided. As will be seen in Fig. 1, an additional transverse slide is provided under the cutter headstock, which, on being moved by a lever, brings the cutter into working position and is automatically latched. The latch is automatically released on the completion of one rotation of the work, and at the same instant the cutter is withdrawn and the feed motion stopped. The saddle carrying the cutter headstock is adjustable along the bed by rack and pinion and a lock bolt is provided. A reference to Figs. 1 and 3 will show that in both the machines illustrated the design is very neat and substantial, while all parts are readily

accessible. Figs. 5 to 7 on page 525 illustrate some methods of chucking shells, shell heads, plugs, &c. for 6-in. and 9.2-in. guns, the times taken to threadmill the screws on these details being given. The other views, Figs. 8 to 21 on the same page show other examples of shells, caps, base plugs, &c., of smaller sizes, with internal and external threads, dealt with in the machines under notice. In all these cases the time occupied in cutting the threads is also given.

INDUSTRIAL NOTES.

The Secretary of the Office of the Labour Adviser to H.M. Government states that a conference of upwards of 100 delegates representing Trade Unions in the engineering and shipbuilding industries met at the Central Hall, Westminster, on November 22 and 23, to consider the extension of the practice of dilution to private and commercial work. The conference was summoned by the Labour Adviser to His Majesty's Government, who presided, and was also addressed by the Minister of Munitions, Mr. Chamberlain, the Chairman of the Man-Power Distribution Board and Lord Derby. After hearing the explanations made on behalf of the Government and deliberating upon them in private, the conference appointed a committee to confer with the Secretary of State for War and the Ministers mentioned above. This committee reported on November 23 to the conference, and the following resolution was thereupon agreed to :—"This conference of Trade Unions representative of the chief unions in the shipbuilding and engineering industries, having considered the recommendation of the Man-Power Distribution Board that the practice of dilution should be extended to firms engaged wholly or partially on private and commercial work, accepts, and agrees to recommend to their members, the principle that dilution shall be extended to private and commercial work." This resolution was conditional upon the observance, where dilution was carried out, of terms at least as favourable to the workpeople as the Treasury Agreement of March 17–19, 1915, and of any Orders, including L. 2 and L. 3, made by the Minister of Munitions, as to the remuneration and employment of men or women introduced as a result of dilution, and also upon the registration of all Dilution Agreements with a Government Department, with a view to the restitution of Trade Union conditions after the war.

A guarantee was also given that skilled men set free from private and commercial work as a result of dilution shall not be taken for general military service so long as they are required either for munitions work or for technical units of the Army, in which their special skill will be best utilised, and the conference agreed that central and local machinery, of which representatives of the Trade Unions concerned should form a part, should be established under the authority of the Minister of Munitions for dealing with allegations of victimisation either in substitution or in de-badging, and with allegations of improper enlistment.

It was agreed that the Emergency Committee of the Engineering and Shipbuilding Trade Federation, together with the committee elected by the conference, should be empowered to negotiate with the Government on any questions arising out of the above proposals.

An interesting case was decided last week at Glasgow, when Sheriff Fyfe dismissed the case put forward by 22 operative plumbers who had applied for leaving certificates upon the ground that they were not paid the recognised rate of wages. The men are members of the West of Scotland and the Glasgow lodges of the United Operative Plumbers' Associations; they work at various locomotive works, and they are mainly occupied in fitting brake pipes on locomotives. They had asked for leaving certificates on the ground that they were not receiving the standard rate of wages of 11½*d.* per hour agreed upon in September last between the Glasgow Master Plumbers' and the Operative Plumbers' Associations. They were only receiving from 10*d.* to 11*d.* per hour, the employers' explanation being that, in practice, operatives employed in manufacturing establishments were not necessarily entitled to and were not accustomed to receive the rate agreed upon for workmen of their class.

In dismissing the men's claim, Sheriff Fyfe said the case was an illustration of how the valuable time of the men themselves, of the employers and of the busy men who were good enough to act as assessors, was frequently wasted by the men bringing applications before the Munitions Tribunal for leaving certificates, upon the ground that they had a difference with their employers in regard to rates of wages. The settling of wages disputes was not the function of the Munitions Tribunal. The tribunal had no power to offer an opinion, and consistently declined to offer an opinion as to whether a rate of pay was sufficient. That was a matter for the Board of Trade and not for the Munitions Tribunal. It was, therefore, quite useless for men to apply to the tribunal with leaving certificate applications based only upon the ground that the district rate of pay was insufficient for their needs. Wages questions had to be regarded from the point of view of how a class of workmen, not an individual workman, was affected, and the legislature had made ample provision for the consideration and remedy of grievances which were beyond the scope of Munitions Tribunals.

One of the miracles of present-day Britain is a place which we will call Moorside, says Sir Arthur Conan Doyle. Only a little more than a year ago it was a lonely peat bog fringing the sea, with a hinterland of desolate plain. Then the great hand of the Minister of Munitions was stretched out to this lonely and inhospitable waste, for it chanced to lie with good rail and water connections and not too remote from centres of coal and of iron. No money and no energy was spared, and half-a-dozen "master hustlers" took charge of the whole great scheme. The work went forward by day and by night. The place grew and still is growing. Already it measures 9 miles one way, with an average of 1½ miles the other. In the daytime there are at least 25,000 busy inhabitants. The greater part are the builders who still extend the township. The smaller are the munition workers who will occupy it all when it is finished. But even now in its partially-finished state its products are essential to the war, and its output has entirely changed all the supply of the present and the expectations of the future. It is not yet fully manned—or "girled"—but, when it is, not less than 12,000 munition workers will be running the miles of factories which overlie the peat bog of last summer. "When I saw these enormous works and the evidences of lavish expenditure," adds Sir Arthur, "I ventured to ask those in authority how the State was to get its money back when, in the dim and distant future, the new world would become ruined and disorganised by the war coming to an end. Was that old patient peat bog waiting so silently below finally to engulf the millions of the taxpayer? The reply was reassuring. All that I had seen up to that point was a good asset and of permanent value. It was all concerned with material which the arts of peace could readily absorb. . . ."

Speaking at a meeting held in Newcastle, last Friday, of the North-East Coast Institution of Engineers and Shipbuilders, on the occasion of the reading of papers on "Works Organisation," Mr. D. B. Morison, managing director of Messrs. Richardsons, Westgarth and Co., Limited, Hartlepool, said he regretted that Mr. Radcliffe, the trade union delegate of the Amalgamated Society of Engineers, had not sent in his contribution to the subject under review, since in order to obtain the progress in industry which from now onwards was of vital importance to the nation it was imperative that labour should not only be sympathetic, but that it should also be actively helpful. Never in his experience had so much time been frittered away by business men as had been wasted by those in control of war work in attending meetings to consider incessant trade union demands, many of which were so trifling that they could, without any danger whatever to trade union principles, be left for settlement until after the war. One of the authors had said that whether the works were large or small, whether the apparatus manufactured was standard or special, the human element was bound to play an all-important part. No works could ever be independent of this factor; indeed, the co-operation of individuals and departments was so vital that it might well be considered as the foundation of the system. "This," added Mr. Morison, "was what might be termed the 'delicate touch,' but what was required were sledge-hammer blows before an impression could be made on our fatuous optimism." For many years he had been familiar with what might be termed "Continental industrial methods," and after every visit to the Continent he had returned home hopelessly pessimistic, because of our sluggish reluctance to see what was going on under our very eyes; and he ventured the opinion that, had there been no war, another twenty years would have left us high and dry industrially. When every other country had found the advantage, indeed, the necessity, for co-operation in research, standardisation of product, and community of commercial interests, not a few manufacturers in this country had as a goal the ruin of each other by suicidal competition, the stronger speculating on the possibility of crushing the weaker, with the result that everyone emerged from the fray necessarily poorer, and in a more or less dilapidated financial condition. On the labour side we had had the recognised policy of restricted effort with the deliberate object of minimising output, and so spreading a given demand over the longest possible period. We knew such a policy led to financial ruin, that it was fundamentally and economically unsound, that if the policy were persisted in we should be hopelessly outclassed by foreign competition, and we knew that for the past twenty years restriction had been preached as a religion, and that to a trade unionist it was now a first principle. He believed the leaders of labour had at last had their eyes opened to the economic fact that high wages must be accompanied by high production, and that they were wishful to correct the teachings of the past, but unless the rank and file understood that the conditions arising out of the war demanded that deliberate restriction should give place to maximum effort, with corresponding remuneration, there would be, before many years, unparalleled industrial chaos in this country.

We are informed that the executive council of the Amalgamated Society of Engineers have addressed to their members a circular containing the text of the agreement recently made with the Government on the question of military service. With reference to this agreement (which will be found on page 502 *ante*), the executive council state the following:—"The members covered by the agreement are clearly stated in clause 2, but special attention is called to clause 1, wherein it is laid down that men 'not now fully engaged' or 'ceasing to be fully engaged on war work shall enrol as war munition volunteers.' It is advisable that all members, whether on war work or not, who are not in possession of a badge and certificate should enrol as war munition volunteers, even though covered by the card which will be issued in accordance with clause 3, but all men employed on private and commercial work will consult their own interests in becoming war munition volunteers, so that they can legitimately hold a card of exemption. It was impressed upon the conference delegates that, while the necessary machinery was being set up to operate the agreement arrived at, some men may still be called up for military service. Where this occurs we were assured that the Ministry of Munitions and the War Office would, on information supplied by the central office, immediately take steps to secure the release of men called up. Instructions have been issued by the War Office to the following effect:—Any journeyman or apprentice, as per clause 2, who receives his calling-up papers, and is willing to be enrolled in the Army as an artificer, should consent to be trade-tested. If he is not willing he should refuse to be so tested, and his calling-up papers will be cancelled pending the issue of the trade card of exemption. Badged and certificated men are in any case exempt, and their calling-up papers, if received, will be cancelled by the recruiting officer. The arrangements whereby skilled men may be found for the artificers' corps in the Army are now under consideration. The scales of wages, &c., will be made known to the members at an early date. The executive council trust that as a result of the agreement the trouble, irritation and perplexity that existed in regard to skilled men in the engineering trade will disappear, and that in future the smooth working of the agreement will enable the executive council to implement the condition laid down in paragraph 2, clause 4, so as to obviate the slightest recourse to statutory powers in the finding of skilled men for the mechanical units of the Army."

A letter, signed T. J. Jones, addressed to the editor of *The Times*, and inserted in last Monday's issue of that journal, states that an immediate settlement of the present dispute in South Wales is essential to the life of our country and must be had, at whatever cost, so as to avoid a stoppage at this crisis, but no such settlement will bring that industrial peace in our coalfield, which is much to be wished. The root cause of the constantly recurring disputes, says the writer of the letter, is human rather than economic. If capital has become "a soulless, dehumanised commercial machine for the extraction of gold out of labour," is it not also fair to say that organised labour has become a machine of similar character for the extraction of wages out of capital? Selfishness is not a class peculiarity. There is fault on both sides, and it arises from a failure to look both upon one's own things and upon those of others. The collier will always, more or less, be a man of grievances, for the simple reason that there are no compensating amenities attached to his toil. All his reward lies in the gold which he earns. That is his own, and he is rampantly individualistic in the disposal of it, hence his corporate surroundings, circumstances and lot are miserable beyond description. No increase of wages to the individual will better his group-self, and, in practice, combination on his part for that end is impossible. Herein he is helpless, but herein the capitalists have a vast field wherein to exercise beneficence. The collier is our brother, and in these days of organised capital it should be the ambition of every company to add to his necessarily meagre happiness and to make provision for that end in its articles of association.

The State has taken over the South Wales mines under new regulations made under the Defence of the

Realm Act, in the terms given in an official statement, and as follows :—

"(1) Where the Board of Trade are of opinion that for securing the public safety and the defence of the realm it is expedient that this regulation should be applied to any coal mines, the Board may by order apply this regulation, subject to any exceptions for which provision may be made in the Order, either generally to all coal mines or to coal mines in any special area or in any special coalfields or to any special coal mines.

"(2) Any coal mines to which this regulation is so applied shall, by virtue of the Order, pass into the possession of the Board of Trade as from the date of the Order, or from any later date mentioned in the Order; and the owner, agent and manager of every such mine and every officer thereof, and where the owner of the mine is a company every director of the company, shall comply with the directions of the Board of Trade as to the management and user of the mine, and if he fails to do so he shall be guilty of a summary offence against these regulations.

"(3) It is hereby declared that the possession by the Board of Trade under this regulation of any coal mine shall not affect any liability of the actual owner, agent or manager of the mine under the Coal Mines Act, 1911, or any Act amending the same.

"(4) Any Order of the Board of Trade under this regulation may be revoked or varied as occasion requires."

Under the new regulation the Board of Trade have made an Order of which the following is the substantive provision :—

"Regulation 9c of the Defence of the Realm (Consolidation) Regulations, 1914, is hereby applied as from the 1st day of December, 1916, until further notice, to the South Wales coalfield, that is to say, to all coal mines in the counties of Brecon, Carmarthen, Glamorgan, Monmouth, Pembroke and Radnor."

In pursuance of this Order the Board of Trade have directed the colliery firms and companies affected by the Order to carry on as usual subject to any further instructions. The President of the Board has appointed an Inter-departmental Committee representing the Board, Home Office and Admiralty to advise with regard to directions to be given under the new Order. The Committee will meet forthwith to deal with outstanding questions as to the general rate of wages in the South Wales coalfield.

THE LUBRICATION OF GEAR-TEETH.

To the Editor of Engineering.

SIR,—Your article on "The Lubrication of Gear-Teeth" (page 119, in your issue of August 11, 1916) is of special interest at the present time. The close agreement of the calculated frictional loss with that found by experiment strongly confirms the approximate accuracy of your determination of the minimum thickness of the oil film.

This minimum thickness, $\frac{1}{1000}$ in., obviously allows of no sensible compensation for deformation of the pinion, gear, or gear casing, which disturb the even distribution of pressure along the teeth and limit the power which may safely be transmitted by a given reduction gear. Would you kindly permit me to give my reasons for differing from the conclusion of the last paragraph regarding the efficacy of the compensation for these distortions afforded by the oil films in the bearings. You state, "Apparently this is to be attributed to the fact that the pinion 'floats' on the oil films between the journals and the brasses." That this does not afford any effective compensation is, I think, proved by both theory and experience.

First. The thinning of the oil film in any one bearing must be due to an undue load coming on that bearing, and this can only arise from unequal distribution of pressure along the teeth. Thus such action in the oil film cannot be nearly a complete corrective of the faulty distribution.

Second. We have evidence that the change of thickness of the oil film in a bearing due to large variations of pressure is exceedingly minute. So far as I know, the only investigation we have of the action of lubricating oil in a bearing is that by Professor Osborne Reynolds (which you also refer to) "On the Theory of Lubrication and its Applications to Mr. Beauchamp Tower's Experiments, &c.," given in the Philosophical Transactions of The Royal Society, Part I, 1886, page 157. Mr. Tower's experiments were made with a journal of 4 in. diameter and 6 in. long. Professor Reynolds' calculations to which I will refer are tabulated on pages 224, 225, Phil. Trans. R. S.; they are for revolutions per minute from 100 to 450 and for pressures per square inch of projected area of bearing from 100 lb. to 415 lb. The results agree in all respects so closely with Mr. Tower's experimental results that the greatest confidence may be felt in their close accuracy. I shall refer only to the column for 450 r.p.m., as that is the nearest to the case for bearings of high speed reduction gears. It is shown that the journal and brass are not concentric; so that there is a point in the circumference where the film is thinnest. The position of this point changes with the load, but the actual minimum thickness hardly alters.*

Third. In a reduction gear in which the pinion is mounted in a floating frame the resultant pressure of the teeth of each helix is automatically kept near the centre of length of the helix, whatever small distortions the apparatus is subjected to. In a gear with fixed bearings there is no such adjustment if, as just shown, the action of the oil film affords no sensible compensation. We would therefore expect that the fixed bearing gear would bear a much smaller safe load than the floating frame gear as the distribution of tooth pressure is upset by minute strains. I have shown in my recent article "On Reduction Gears" (ENGINEERING, vol. ci, p. 415. See "Data of Power Constants, &c.," p. 491, and "Interpretation of the Power Constant," p. 519) that floating frame gears safely bear a load from two to three times as great as that at which fixed bearing gears are usually run.

It does not follow, as appears to be assumed in your last paragraph, that because teeth are polished all over the pressure must be uniform. When a grinder polishes a surface he only makes contact between the emery wheel and a small portion of the surface at one time.

In your second last paragraph an interesting and important question is raised by the statement, based on the conditions of lubrication, that "so far as security against abrasion is concerned, it would seem that the permissible load per inch of pinion length will vary with the square root of the pinion diameter." I think this conclusion is modified by two considerations not assumed in your investigation :

(*a*) The highly localised stress near the "point of contact" of the teeth will cause slight flattening of the surface, increasing with rise of pressure. Hence, the higher the tooth pressure the more difficult will be the escape of the oil and the minimum thickness of the film will be kept up slightly.

(*b*) I have shown in my article already referred to (ENGINEERING, vol. ci, page 520, "Number of Teeth"), by considering similar gears, that for the best results the number of teeth in the pinion should be constant; hence the pitch will be proportional to the pinion diameter. Thus the length of the path of contact will increase more than for constant pitch, which change will raise the allowable increase of pressure per inch length of pinion, notwithstanding that rather fewer teeth will now be in contact than if constant pitch had been retained.

Considerations (*a*) and (*b*) will, I think, allow of a rise of pressure per inch more nearly in proportion to the pinion diameter than that you give. This direct proportionality, as is well known, is the law deducible from considerations of strength and elasticity alone. That the law of direct proportionality is correct is supported by the practice, successfully used in calculating pinion diameters, that the allowable "power constant" is independent of the size of the gear.

I am, Sir, yours truly,
JOHN H. MACALPINE.

5,845 Phillips Avenue, Pittsburg, Pa.
November 3, 1916.

TESTS ON A DIESEL ENGINE.

To the Editor of Engineering.

SIR,—I was interested to see in your last issue a letter from Mr. Mickelsen on the above subject, with special reference to Professor Burstall's remarks. Any Diesel engineer of experience will know that the figures given by Mr. Mickelsen are correct, and I think that those of your readers who are interested in the subject will appreciate this gentleman's corrections.

There appears to be a sort of conspiracy amongst qualified Diesel engineers to keep their information to themselves, and it is gratifying to meet with exceptions to this rule. I was once present at a meeting of the Institution of Naval Architects at which were read two papers on Diesel engine subjects. The outstanding feature of the discussion was the unanimous silence of all gentlemen present who had any special knowledge of the subject. The most humorous item of the discussion was supplied by a marine engineer, who wished to see the design of Diesel engines simplified by locating the air compressor and other important items inside the pistons. We have heard a lot recently about co-operation between manufacturers, but it is rather significant that any movement in this direction by Diesel engine builders appears to have failed to secure the co-operation of those manufacturers who have had the longest experience. This is very regrettable, as there is not much to be gained by pooling ignorance, and it appears to me that economy would be achieved in the end if firms desiring to take up the manufacture of Diesel engines would appreciate the value of expert knowledge and experience and pay for it accordingly.

The Diesel Engine Users' Association is making public a lot of useful information, and I am sorry to see that its proceedings are not reported in your columns.*

Yours faithfully,
M. H. PURDAY.

147, Abbey-road, Barrow-in-Furness,
November 24, 1916.

*[Our correspondent is in error; numerous reports of the work of the Diesel Engine Users' Association have been published in ENGINEERING.—ED. *E.*]

"SPARK IGNITION."

To the Editor of Engineering.

SIR,—The table given by Mr. W. Gullette in your issue of the 17th inst., page 479, would seem to be the result of tests taken by one individual or firm, and as such may be a biased opinion in favour of the magneto. In the *Autocar* of November 11 there appeared extracts from a lecture read before the Institution of Automobile Engineers on November 8 by Mr. A. Ludlow Clayden, and from which the following is a brief extract :—

"As evidence from a source which is unbiased, the author can only quote the Packard Company, of Detroit. This concern is one of the few in America which is able to consider price as a secondary matter, and it only abandoned the magneto after a long series of tests on the dynamometer and on the track. The conclusion reached was that there was nothing whatever to choose between the magneto and the battery at moderate and high speeds, but that with low crankshaft speeds the magneto was unreliable. These tests were made with different ignition devices, and the author is satisfied that they were conducted without any prejudice whatsoever."

In view of the fact that the figures given by Mr. Gullette are of American origin, it is interesting to note that in a recent issue the American *Automobile Engineer* it was stated that for the year 1916 only 18 per cent. of American cars were designed for magneto ignition, the remaining 82 per cent. being fitted with battery ignition.

Surely this is a proof of the opinion of American automobile manufacturers on the subject. Perhaps Mr. Gullette will explain why this is the case.

Yours faithfully,
November 27, 1916. JOHN EDMUND.

ELECTRON, QUANTA AND RELATIVITY THEORIES.

To the Editor of Engineering.

SIR,—While thanking Mr. Edwards for his kind allusion to myself in to-day's ENGINEERING, I feel that he is wrong in supposing that "engineers and amateurs alike have ceased to discuss" subjects on which he has "spent 20 years in trying to fathom." It is because of our serious study of what Relativists try to say that we question the soundness of their claims; and it is not always the fault of the student that he cannot "understand the point of view" of the teacher. The latter may get into the condition of believing himself possessed of a special sense—just as some religious folk think they have a spiritual sense which others lack, or as some unfortunate fellow-creature imagines himself to be a poached egg—and it is no good attempting to argue with such people.

Mr. Edwards's diagram consists of a rectangular hyperbola which has been used for many years to illustrate Boyle's law, pv = constant; then there is a sphere, the surface and contents of which cannot be ascertained because the exact value of π is not known: and then we have a few statements which appear to me absurd. For instance, how can an "amount of energy or momentum" *enter* at W or anywhere else? Why say that "MN is the locus of a series of rectangles," when $xy = k$ is merely an equation to a curve?

When your respected correspondent writes about Wien's and Stephan's fifth and fourth-power laws, and he tells us that "the whole diagram can be transferred from ether to water," I can hardly resist the temptation to transfer it from air to fire. But I am sure Mr. Edwards could give us, and I beg to thank him in anticipation for, something of his own more valuable than simple references to the work of others, some of whom spend their time in calculating how many angels can dance on the point of a needle.

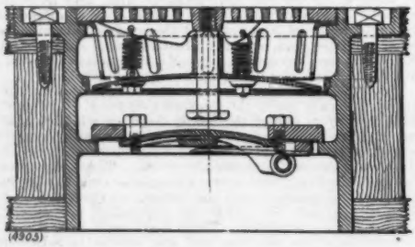
November 24, 1916. SESAMY.

GUN-PROVING.—What is claimed to be the largest gun-proving plant in the world is to be established at May's Landing, a few miles from Atlanta, New Jersey, by the Bethlehem Steel Company, primarily for the use of the United States Government. Nearly 1,000,000 dols. have been expended in the purchase of land, and another 500,000 dols. will have to be paid out before proving can be commenced. A fine state boulevard extends along one side of the tract and an electric railway runs on the other side. The site of the proving ground renders it possible, in the event of war with a sea power which would attack the Jersey coast between New York and Philadelphia, for the American Government to develop it as a military base. With a little dredging the inlet and the large bay could be made navigable for warships, while coast waterways connect with New York harbour and the Delaware.

* In the notation of Professor Reynolds' paper this minimum thickness is given by $a(1-c)$ where a is the difference of radii of the brass and journal and c is the ratio of the distance between the centres of the brass and journal to a. The minimum thickness can, therefore, be at once deduced from the calculated values of a and c per entered in the table). The values for 100 and 152 lb. square inch of journal pressure are .00122 and .00129 in., giving a change of only .0007 in. I give these values because the load of end pinion bearings in high speed reduction gears is in the neighbourhood of 100 lb. per square inch. The greatest and least values of this minimum thickness for loads from 100 to 415 lb. per square inch (the latter being far beyond the limit for reduction gear bearings) and, as before, 450 r.p.m., differ only by .00019 in.; and, taking account of the changing position of the point of minimum thickness, the changes, both vertically and horizontally, of the centres of the journal and brass, in these wide limits, are of the same order of magnitude. Hence I conclude that no adjustment of any value can be hoped for from this source. (As the minimum thickness of bearing oil film in the cases referred to above are all little over 1/1000 inch and as the oil escape from the convex surface of the teeth is so much freer than that in the bearings, it is evident that the film of oil between the teeth must at all times have some such excessively minute value as you calculate; affording, as stated above, no sensible means of adjustment.)

EMERGENCY BILGE VALVE.

There have been cases of vessels coming into port with several feet of water in some of the holds, although the ship was fitted with admirable pumping plant and the pump suctions were all unobstructed. It was not the fault of the engineer, but of the construction of the vessel, for the water was above the ceiling and the pump suctions below, and between the two was an impermeable ceiling with limber hatches. Pump suctions must, of course, be put low, else they cannot keep the bilges dry, and, further, they must be protected from coal dust, wheat and other loose cargo, or they will be found to be stopped when the pumps have to be worked. Consequently the ceiling of the hold, which in spite of its name is really the floor of the hold, must be tight fitting. Under the centre part is the double bottom, which is utilised as a ballast tank, and has pumps and suctions of its own. Leakage through the ship's side, above the margin plate, cannot, of course, get into this tank, and is supposed to run down



into the bilges. But in the case of insulated holds this is quite impossible, and in many other vessels the ceiling is so close fitting and the hatches are so carefully applied in order to keep out dust, that the water cannot get through if it enters the vessel above the level of the bilge ceiling. Hence it sometimes happens that a very dangerous load of water may be taken on board and there is no means of getting rid of it.

To meet this difficulty Messrs. J. Stone and Co., Limited, of Deptford, are introducing the emergency bilge valve shown in the above illustration. It is, as will be seen, a valve of large diameter held up against a stop by light springs. It is carried in an outer iron casing which is fitted into the bilge hatch in the lower insulation. A grating above it prevents the entry of solid objects, but allows easy access to water. In the case of insulated holds the space below the grating can be filled with charcoal, which will be carried by the springs. Further access of water will depress the valve, which has no seating to stick, and will accumulate on the lower valve, until that opens. This is a flat valve, normally held up by a light spring. This is designed to prevent the passage of air and water from the bilge to the hold.

THE HARE BORING TURRET LATHE.

The accompanying illustrations show a boring turret lathe which is largely a product of the war, since it has been designed specially to bore shells from 4 to 8 in. diameter. The designer has kept in view the necessity for high speeds and large feeds, and consequently strength and stiffness are the prominent characteristics of the lathe. One feature conducing to stiffness is the size of the spindle, which is able to receive the shell inside it, so that the work lies partly with the front bearing. The front headstock bearing is 8½ in. in diameter by 12 in. long, and is made in one piece with the 15-in. heavy flange to which the chuck is bolted. This is of the collet-sleeve type and drives the shell through three self-centring steel jaws.

The bed, the headstock and the legs are all cast in one piece. The bed is very deep, and is 9 ft. long. It carries flat shears, each 3 in. wide, and on them runs the carriage, which is 42 in. long. In the centre of it is a steel rack, 3 in. wide and 4 in. diametral pitch. The centre of the boring bar is only 6 in. above the shears.

The turret is 20 in. outside diameter and of circular design. Six holes are provided, $3\frac{5}{16}$ in. diameter, fitted with ½-in. square keys on the under side, and with two ⅝-in. set screws for holding the boring bars. While a very heavy central stem has been provided on the carriage, the turret is spigoted at its outer edge, thus providing a wide base to resist the tool pressure. A hole has been provided through the centre stem for driving out the boring bars. The turret is fitted with a hardened steel ring, tempered and ground, into which a hardened steel key is fitted, thus holding the turret firmly in any chosen position. The clamp on top of the turret is very heavy, the stud being 1¾ in. diameter.

The main gear, which is 4½-in. face and 3 diametral pitch, is fitted to the spindle on a diameter of 9½ in., which provides ample driving power. The back gearing has a ratio of 9 : 1. The cone pulley has two speeds, provided by 15-in. and 18-in. pulleys, and carries an 8-in. double belt. The back gear has a 3½-in. face, 4 diametral pitch, and is driven from the cone pinion, which is made of special electrical cast steel. The thrust of the tool is absorbed by a special self-adjusting "Skefko" thrust bearing fitted with a dust-proof self-oiling case of cast iron, and capable of a continuous working load of 8,400 lb.

The feeds are four in number, being $\frac{1}{64}$, $\frac{3}{64}$, $\frac{5}{64}$ and $\frac{7}{64}$ in. The wide range thus provided covers all rough and finish cuts. No gears have a narrower face than $1\frac{5}{8}$ and $1\frac{7}{8}$ in., while the smallest pitch selected is 6 diametral pitch. The worm gear on the power feed is 4 diametral pitch, geared 50 to 1 with a steel worm. Ball bearings take up all the thrust of the worm and transmit to the frame. The capstan bars are 24 in. long, and the gearing provides a thrust of 79 lb. on the tool for 1 lb. on the capstan. It will be seen that about 25 lb. on the capstan gives 2,000 lb. on the tool.

The weight of the complete lathe for the 4.5 in. or 6 in. shell is 8,000 lb. on skids ready for shipment, including countershaft, chuck, oil pump, &c. It is constructed by the Reliance Machine Company, Toronto, Canada.

THE HARE BORING TURRET LATHE.

CONSTRUCTED BY THE RELIANCE MACHINE COMPANY, TORONTO, CANADA.

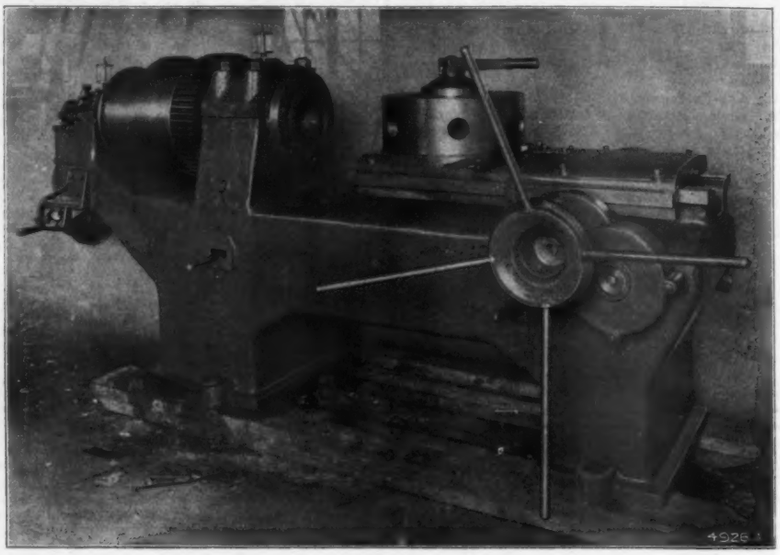


Fig. 1.

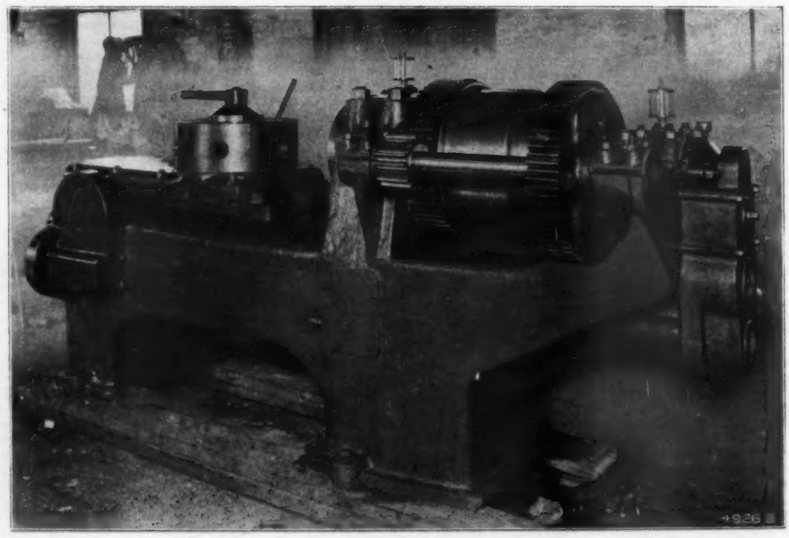


Fig. 2.

German Iron in Denmark.—On account of the difficulties which have been raised in Germany with regard to the export of German iron to Denmark, representatives of the Danish iron industries have visited Germany, and the negotiations are likely to lead to a satisfactory arrangement, so that the supplies will be secured till some time in the spring. A central bureau has now been formed in Denmark for the purpose of distributing the iron received from Germany.

University College, London.—We have received a copy of the new calendar for University College, London. The dean of the faculty of engineering here is Professor E. G. Coker, whilst Professor J. A. Fleming is vice-dean. In addition to departments devoted to civil, mechanical and electrical engineering, there are special courses on municipal engineering, of which the professor is Mr. E. R. Matthews, A.M.Inst.C.E. Mention should also be made of the special courses on town planning and civic engineering, under the direction of Professors Adshead, Matthews and Kenwood.

DESIGN OF SUBMARINES.

On the Suitability of Current Design of Submarines to the Needs of the United States Navy.

By CAPTAIN W. L. RODGERS, U.S.N., Associate.

IN accepting the invitation which the secretary of the society did me the honour to extend in asking me to contribute a paper on submarines, I do not assume that he had any idea that I would undertake to tell the members of this society anything in regard to the technical and mechanical features of submarines, with which they are already well acquainted.

But I was president of the Naval War College some years ago, and ever since I have given attention to the strategic and tactical fields of work which are open to submarines in naval warfare. A sketch of these fields and a consideration of possible modifications and variations in design of submarines to meet the requirements of warfare seem to me to offer interest to naval architects, and it is along these lines that this paper will be developed.

In thus discussing the subject, it must be borne in mind that while the constructional and engineering possibilities of design are pretty well known, and form a stock of knowledge common to designers of all nations, nevertheless the application of this stock of knowledge to the production of concrete designs suitable to the national policy and geographic situation of particular nations will result in types of ships which will differ much according to nationality. This paper will consider some of the controlling factors which should influence American design. In so doing we need not fear the betrayal of any national secret. It is the business of foreign navies, through the agency of their general staffs, not only to study in advance the requirements of their own forces, but also to examine the situation of other powers which may become hostile to them, so as to draw deductions as to the enemy's probable efforts and employment of his forces.

Any enemy in thus considering our types of submarines and their probable employment in war will no doubt start from very much the same premises as we ourselves assume, namely, the well-known constructional possibilities of submarines varying with the progress of invention, the tactical development of the present war in attack by, and attack upon, submarines; and, finally, the national policies and geographic situation of the United States.

Assuming the enemy has equally good reasoning power as ourselves, and granting he knows the ordinary constructional data as to submarines, it is clear that he will necessarily arrive at conclusions much like our own. If we avoid general discussion in the hope of withholding information from foreigners, it is ourselves who will suffer most, since goodwill and a common understanding between the seagoing navy and the industries which support it are essentials to success, and particularly necessary in a democratic nation. In fact, a basis for such a common understanding is provided in the public hearings upon the Naval Appropriation Bills, which give much information as to our policies and views.

The purpose of this paper will, therefore, be first to examine the peculiar military characteristics of submarines in general and compare them with those of other types of combatant ships; second, to consider how these general characteristics will influence or control the employment of submarines in war; and, finally, what particular types of submarines seem best suited to American needs.

Submarines are armed with torpedoes and with guns. Owing to the great percentage of the displacement which is necessarily devoted to the heavy hulls and very heavy machinery installation, the speed of submarines is much less than that practicable for surface craft of the same size. Consequently submarines, unlike torpedo boats and other fast craft, cannot rely on their speed as a means of safety. For the submarine the chief means of defence is provided by her submersibility and consequent invisibility. Further, the great weight of storage batteries forbids giving submarines more than a small radius of action when submerged. The submarine obtains information only when able to see—at the surface. She can navigate freely and recharge her storage batteries only when running the oil engines at the surface. These are the chief peculiarities which affect the combatant powers of submarines. They affect alike those submarines which are armed with torpedoes and those of that other type, the fruit of the current war, which are designed as mine layers. Bearing these peculiarities in mind, we may proceed to consider the general principles which these qualities require a captain to observe in the employment of a submarine under his command.

In regard to the torpedo, a peculiarity exists which differentiates its use very much from that of the gun. The initial velocity of a projectile from a high-power gun is 3,000 ft. per second. The speed of the fastest ship is not over 60 ft. per second. As these two velocities are in the ratio of 50 to 1 a ship cannot escape from a projectile fired at her. The greatest velocity of an automobile torpedo seldom exceeds about 40 miles an hour, and this only for moderate ranges. By reducing the speed to 30 miles or less an hour the compressed air in the flask can drive the torpedo further, but such speeds are of the same order of magnitude as those of the target ship. Consequently, the direction and speed in which the target ship is moving are most important elements in deciding when she is within range. Consider, for instance, a 30-knot torpedo capable of running 10,000 yards. If fired at a ship approaching at the rate of 20 knots there is a chance of hitting if fired at a distance of over 16,600 yards, whereas if the target is withdrawing at 20 knots the torpedo will exhaust its motive power and stop before overtaking the target if fired from any range above 3,300 yards.

When submerged the submarine itself also is limited both in speed and radius—12 miles at most at 10 or 12 knots, 100 miles, more or less, at 5 or 6 knots. Thus when submerged the submarine's area of action resembles that of the torpedo which it carries as its chief weapon. It cannot chase to advantage when submerged. We cannot give a submarine the highest surface speed because of the heavily built hull and the heavy storage batteries. Such surface speed as we are able to confer on a submarine is inadequate for the tactical requirements of battle. It may enable a submarine to assume a favourable position for submerging ahead of an approaching enemy, but it cannot be great enough to be satisfactory in the tactical approach, as is the case with the torpedo boat at 30 knots, which relies upon her great speed as a means of protection when charging upon the enemy. As the submarine when submerged cannot hope to overtake its target it must lie in wait for the target to come to it.

Thus limited to moderate surface speed and low submerged speed, and unable to increase weight by the addition of armour, the submarine is obliged to rely upon her faculty for concealment as her chief means for employing her weapon, whether mine or torpedo. But concealment entails disadvantages. In hiding herself she becomes blind, and if by the adoption of the periscope she has recovered partial sight, she has sacrificed a corresponding measure of invisibility. Before concealing herself to attack, the submarine first must sight her enemy in order to direct her attack. To accomplish this to best advantage she must rise and search the horizon with natural vision. Unfortunately when so doing she cannot promptly submerge, and is therefore liable to surprise attack. The submarine's difficulty in seeing has consequences which extend beyond the individual ship. In warfare there is a combatant advantage in superior numbers which is greater than the numerical ratio of the hostile forces (as may be mathematically shown). For this reason it has always been reckoned a great point, both ashore and afloat, to bring superior forces to engage simultaneously upon the field of battle. But the submarine's imperfect vision occasions danger of interfering with friends when large submarine forces are concentrated for simultaneous concerted action, such as does not occur in the assemblage of any type of surface craft. Thus the submarine is not only an arm to be used by stealth, but its most favourable opportunities occur in dispersed and solitary action rather than in concentrated and co-ordinated action.

Having thus glanced at the offensive and defensive capabilities of submarines, we may now turn to the means of parrying their attack and of overcoming it.

Until the outbreak of the current great war there seemed to be no adequate defence against submarine attack, but necessity is the mother of invention in tactics as well as in material, and there is less to fear from the submarine now than at the outbreak of the war. The great ships which the submarine would most gladly meet find their best protection is rapid motion; for the slow submarine, seeing imperfectly, is disconcerted by swift movement, more especially if this accompanied by frequent alterations in direction. But ships cannot be always on the move and it is necessary to provide both passive defence and active counter-attack against submarines. For harbours and certain sea areas the passive defence is furnished by wire nets, whose meshes are of a size suitable for catching submarines, while the counter-attack is made by thousands of swift patrol boats whose business is to destroy the submarine or force him down again whenever he comes to the surface for information or for air to start his engines and to recharge his batteries.

The success of these measures against submarines is undeniable. At the beginning of the war German good fortune with submarines promised the most important results, but as the war drew on the efficacy of submarine warfare diminished as methods of reply to it developed. It is now an important arm, but not the supreme one. By a line of *a priori* reasoning the general broad conclusion to be drawn from this survey is that the submarine is essentially a defensive arm, whose use as an offensive arm, although practicable, yet partakes somewhat of the nature of a *tour de force*.

After this brief review of the general qualities of submarines and the probabilities open to them, we are ready to take up the consideration of the particular types of submarines best suited for American use. Preliminary to this examination it will be desirable to summarise the accomplishments of the submarine under the conditions imposed by the relative situations of the present belligerents.

The early performances of German submarines caused them to stand very high in popular estimation, but they have not yet been able wholly to justify the expectations they first aroused. The efforts of Germany to wrest the control of the sea from the grasp of Great Britain and her Allies called for the exertion of the highest type of offensive war; but, as we have already seen, the submarine, in its essential nature, is the defensive weapon of the weak. It met with a temporary success, first in the North Sea and later in the Mediterranean, which in each case lasted only until the Entente Allies had time to prepare counter measures. At the opening of the war British ships advanced boldly to the German side of the North Sea and manœuvred there at slow speeds. The hostile submarines took advantage of their opportunity, and the British forces withdrew from the vicinity of the German coast. Great Britain then developed the net defence of her ports and of the cross-channel routes to France, as well as the counter-attack against hostile submarines and mine-layers by the patrol flotillas, of whose work such an excellent idea is given in Kipling's "Fringes of the Fleet." After six months of warfare the Germans began their submarine attack upon commerce. The strategic features of this phase of the war need our consideration.

German submarines were charged with the aggressive task of destroying commerce, but owing to their essentially defensive nature they were obliged to lie in wait in positions where shipping would come to them. The favourite area was that between the south of Ireland and the western entrance of the English Channel, since nearly all British foreign commerce naturally took that way. But as the Straits of Dover were protected by nettings the Germans were obliged to pass around the North of Scotland to reach their station, a distance of about 1,200 miles. Once there, it was necessary to lie on station some days in order that the time at work might be in reasonable proportion to the time needed to make the trip and return. Thus, as a matter of logistic economy, the submarine employed on this service required a large radius of action, which entailed a considerable size—about 800 tons. Our attention has been particularly centred on these large craft because their deeds attracted most notice, but they are not the only ones employed. We have every reason to believe that, where submarines are needed for their proper defensive rôle to protect the German coasts, much smaller ones are used. Similarly, the English—who have the mastery of the sea, yet need submarines to aid in the protection of their ports against sudden raids—make use of small ones. So far as we know, submarines have accomplished little or nothing during the current war when acting in company with the main fleets. At the Battle of Jutland last May they seem to have been absent or ineffective.

The evidence of the present war as to submarines may be summarised by saying that on both sides they have obtained a degree of success in defence, to the extent of forbidding the approach of the main fleets of both sides to hostile coasts. In this successful coast defence submarines have been greatly aided by mines.

The use of submarines for the purpose of strategic attack has been less successful, although Germany's attack, in particular, has arrested much attention. The submarine strategic attack has been chiefly directed against commerce, by the British and Russians in the Baltic Sea against German trade with Sweden, and by the Germans at the entrance to the English Channel against the ocean trade of France and Great Britain. While this destruction of commerce has been serious, it has not led to conclusive results, although the narrow waters in which this contest has taken place have been favourable to the efforts of submarines because commerce has been obliged to cross the areas infested by them.

In estimating the value of submarines in the current war we must not attribute the present shortage of commercial shipping wholly to the deeds of submarines. In the order of their importance the factors in this shortage seem to be:—First, the great military and naval demands made upon commercial shipping; second, the internment at home or abroad of all or nearly all shipping of the Central Powers; third, the delays imposed upon Allied shipping by the patrol and mine-sweeping services, which have adopted a retardatory but necessary administrative system for the protection of ships passing through dangerous areas; fourth, the actual loss of shipping caused by submarines, which seems to have been about 3 per cent. a year, more or less, nearly the same the English merchant service encountered without serious consequences in the Napoleonic wars.

The foregoing discussion has had the objective of placing us in a position to consider what type of submarine will best suit the requirements of our own navy, and this we shall now proceed to do.

The geographic situation of the United States, with a very extended coast-line, much of which is remote from possible enemies and borders great oceans, is very different from that of the present combatants, who are separated by comparatively narrow waters and confront each other at relatively short ranges. As we have seen, the submarine is essentially a defensive arm. It finds least opportunity when it meets its enemy in the open sea with full freedom for manœuvre. On the contrary, the submarine is favoured when its enemy approaches a hostile shore, where his freedom of manœuvre is hampered by the proximity of the coast and his advantage of speed is thereby partially counterbalanced. Therefore it does not seem desirable that our navy should attempt to establish a defensive cordon of submarines far from our coasts in mid-ocean. For a line held there will be long; its distance from shore will require much time to arrive at and return from station, necessitating excessive numbers of ships. The enemy has no objective in mid-ocean and will not wait there. If he is attacked in that neighbourhood by submarines, he has the advantage of full opportunity to manœuvre freely at high speed. On the other hand, our submarines will gain on every one of the above-mentioned points if they are used for local coast defence and do not go far off shore—say, not more than a day's run. They may well expect to maintain a strip of coastal waters fairly free from the enemy and available for coast navigation, as do the English at the present time. Thus the size and type of coast-defence submarine of about 500 tons now favoured by our Navy Department seems the proper and logical one for American use. It is true that it is a much larger type

* Paper read at the 24th general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1916.

of submarine which has obtained most Press notice in the current war, but that is because the requirements of the situation were such that the areas best suited to the operations of German submarines were far from German bases. We do not foresee any strategic reasons that will require our submarines to operate so far from home. American coast defence does not appear to require the largest type of submarines. Nevertheless, the Appropriation Act of this year calls for three of a large size (800 tons), which will prove instructive and useful as experimental boats even if they prove to be larger and more expensive than necessary. There is a great desire on the part of every navy to provide submarines capable of accompanying the fleet and taking part in general actions. For such a purpose a second type of submarine is necessary.

Such a craft will be away from its base for a longer time than coast-defence submarines, and must, therefore, have a larger crew and better quarters. Tactically, also, its requirements must be quite different. As was earlier pointed out in this paper, an automobile torpedo has a greater virtual range when it is fired to meet an approaching target than when it is fired to overtake a retreating target. Consequently an ideal torpedo boat, whether of the surface type or of the submarine type, should have superior speed to that of its probable opponent in order that, however the latter turns, the torpedo boat may assume an advantageous position ahead of the enemy before closing to discharge the torpedo. But this is a difficult condition to satisfy with a fleet submarine. The standard speed of battleships reached 21 knots some years ago, and is now on the rise once more. At present 23 knots may be regarded as the normal speed for foreign battleships of the most recent design, and our navy should not lag behind others in this respect. An ideal fleet submarine should have both surface and submerged speeds not less than 25 knots, and a submerged radius of at least two hours at maximum speed. Unfortunately, we cannot get a quart into a pint pot, nor is such an ideal fleet submarine practicable. No submarine even of as large size as 1,200 or 1,500 tons, can get sufficiently powerful machinery into her; first, because her hull weight must be great to withstand submergence, and, second, because she must be provided with two heavy systems of motive power, in place of one lighter one, such as surface craft have.

In the present state of engineering we shall therefore be obliged to content ourselves with a surface speed approaching the cruising speed of the fleet under war conditions, or about 20 knots. The submerged speed and radius must be very moderate: sufficient only to serve as a means of passive defence by concealment, but not enough for aggressive manœuvring while submerged. The mechanical limitations thus imposed upon fleet submarines restrict very greatly the tactical freedom of the commander-in-chief who attempts to utilise submarines in a general engagement. Other component elements of the fleet are all capable of acting in mutual support of each other in aggressive attack upon the enemy. The fleet submarine, limited as it is in speed, is incapable of such co-operative attack with other types, for it cannot force itself into the fight. The commander who seriously relies upon his fleet submarines in a general action must place himself upon the strategic defensive and so restrict his freedom of manœuvre as to make it a chief objective to draw the enemy within the pre-established area of the submarines. It is clear that such a limitation is a severe handicap. It is nevertheless desirable that our fleet should be accompanied by submarines for use when opportunity serves. Those now building are abreast of present possibilities, but should be improved and developed in succeeding years as engineering progress dictates. The chief distinguishing characteristics for them are high surface speed with adequate surface endurance and habitability. High submerged speed and great submerged radius are comparatively secondary affairs unless most radical improvements are brought about in the methods of submerged propulsion, so that high submerged mobility may be obtained without undue sacrifice of surface mobility.

The conclusion to be drawn from this study is that the Navy Department has made a judicious decision in the combination of military characteristics which it has embodied in its latest designs of submarines for service with the fleet as well as for coast defence.

Prohibited Exports.—A supplement to the *Board of Trade Journal* of November 23 contains complete lists of articles which, according to the latest information received by the Board of Trade, are prohibited to be exported from Denmark, France (including Algeria), Greece, Italy, Japan and the Netherlands. This supplement also contains the list of articles (complete to date) which are prohibited to be exported from the United Kingdom. The supplement may be obtained from the usual sale agents for Government publications, price 3½d., post free.

Annual Inspection of Commercial Motors.—The eleventh annual inspection of commercial motors and examinations of drivers, organised by the Commercial Motor Users' Association with the object of encouraging drivers, by means of money prizes and other awards, to take a personal interest in the driving and condition of their vehicles, and to run them without accident, will take place in London during May, 1917; but the usual assembly, or parade, of vehicles will not be held, owing to the difficulty of sparing vehicles from service during the present period of stress. Full particulars and entry forms may be obtained from Mr. Frederick G. Bristow, F.C.I.S., secretary, the Commercial Motor Users' Association (Inc.), 83, Pall Mall, London, S.W.

NOTES FROM THE UNITED STATES.

Philadelphia, November 15.

Activity in the steel market is greater at the present time than since the new conditions presented themselves. Prices have been steadily advancing and an upward tendency is still threatened; this is indicated to a certainty by the bulk of inquiries which have been presented within a week. European consumers are offering prices for supplies higher than manufacturers are asking. This complicates the situation. Manufacturers are strongly inclined to take care of home concerns, even under the temptation of higher prices. Where near-by deliveries are probable, all sorts of premium prices are offered and accepted. The Steel Corporation gained 500,000 tons during October, and has now over 10,000,000 tons of unfilled orders. The railway systems at home are obliged, notwithstanding their unwillingness to pay such high prices as are ruling, to come into the market with large orders for locomotives, cars and other equipment. The orders for locomotives are exceeding all records. The country is threatened with serious traffic congestion for lack of cars, and no possible expedients are within reach. Crude iron has made another advance under an enormous demand, especially for basic and Bessemer. The furnaces are unable even to consider all the business offered. Southern iron is in active demand for export. The French Government is negotiating for some 50,000 tons of structural shapes for delivery during the first half of next year. Another inquiry is on the market through Morgan for 50,000 tons for export. Wire prices have again been advanced 3 dols. per ton, making 12 advances within 11 months. The prolonged duration of the war is leading to a new set of conditions which will affect the steel trade for the latter half of next year in the direction of a marked advance in prices, and this will affect all domestic contracts seriously. The railroads cannot get orders accepted for all the structural material they absolutely need. Italy has just secured the acceptance of an order for 12,000 tons of steel plates. Railroad earnings are very large, and at various points thousands of cars are standing because of over-crowded terminal facilities. The fuel question is becoming a still more serious one.

Boiler Fittings.—On page 519 of our issue of November 24 we published a paragraph headed "Boiler Fittings," in which we described regulators for boiler feed, for steam feed to feed pumps, and for the steam supply to furnace jets. It was stated that these apparatus were constructed by the Crosby Steam Gauge and Valve Company. We have since been informed that this company have sold their European business to the Crosby Valve and Engineering Company, Limited, of 147, Queen Victoria-street, and that the apparatus described are made by the latter firm under their own patents.

Reform of the Civil Service.—The Lords Commissioners of His Majesty's Treasury have appointed a committee constituted as follow:—Mr. Stanley Leathes, C.B., First Civil Service Commissioner (chairman); Sir Alfred Ewing, K.C.B., F.R.S., vice-chancellor of the University of Edinburgh; Sir Henry Alexander Miers, D.Sc., F.R.S., vice-chancellor of the University of Manchester; Mr. H. A. L. Fisher, M.A., F.B.A., vice-chancellor of the University of Sheffield; Professor W. G. Adams, M.A., Gladstone Professor of Political Theory and Institutions in the University of Oxford; to consider and report upon the existing scheme of examination for Class I of the Home Civil Service; to submit for the consideration of the Lords Commissioners of His Majesty's Treasury a revised scheme such as they may judge to be best adapted for the selection of the type of officer required for that class of the Civil Service, and at the same time most advantageous to the higher education of this country; and, in framing such a scheme, to take into account, so far as possible, the various other purposes which the scheme in question has hitherto served, and to consult the India Office, the Foreign Office, and the Colonial Office as to their requirements, in so far as they differ from those of the Home Civil Service. The secretary to the committee is Mr. D. B. Mair, M.A., Civil Service Commission, Burlington Gardens, W.

The Corrosion and Electrical Properties of Steels.—At the meeting of the Royal Society held on November 23 an interesting paper on this subject was read by Sir Robert Hadfield, F.R.S., and E. Newbery, D.Sc. The condition that a metal shall dissolve in an acid with evolution of hydrogen is: Single potential of metal + over-voltage < single potential of hydrogen electrode, all measurements being, of course, made in the given acid. If, therefore, we assume that the atmospheric corrosion of a metal is a process similar to that of dissolution in an acid, it should be possible to predict the corrosion-resisting power of a given metal by determining its single potential referred to a hydrogen electrode, together with its over-voltage in a suitable electrolyte. Experiments on a number of special steels have been carried out to test the validity of the above assumption. The over-voltage, single potential and loss of weight in acid of each specimen was determined and compared with the atmospheric corrosion observed after exposing clean surfaces to the air for ten weeks. The results showed that the electrical method gives decidedly better estimates of the corrosion-resisting powers of steels than the acid method, and although neither method gives reliable estimates in all cases, yet the electrical method appears to rest upon a sound theoretical foundation, and is probably capable of further developments which may result in the formation of reliable corrosion data.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—The only feature of any note which falls to be recorded in connection with the pig-iron warrant market is the continued depletion of the stocks in public store. Otherwise affairs remain at a complete standstill.

Scotch Steel Trade.—The pressing demand for all classes of manufactured steel required by the home and the Allied Governments shows no slacking off, and an ever-increasing activity prevails in the steel-making establishments in the West of Scotland. Every effort is being made to keep pace with the demand. A further attempt is being made in various directions to lay down additional plant, and if the new scheme of dilution of labour can be satisfactorily exploited, considerable progress should be the result. The requirements of the Government leave little material available for ordinary mercantile work, although inquiries are plentiful. For export also there would be good business were it not for the stringent and necessary licensing restrictions. No alteration in price has taken place during the past week, although developments are not unlooked for.

Malleable Iron Trade.—Business in the malleable iron trade continues to run on eminently satisfactory lines, every mill, alike in the iron and the steel departments, being kept going unceasingly, while practically the entire production is being consumed at home. The Government barrier on the shipment of steel abroad has had the effect of considerably curtailing the general trade in malleable iron, but probably this is more than made up by the insistent demands for material on Government account. This is specially noticeable in the steel departments, considerable quantities, both of Siemens-Martin and shell discard quality, being in great request. For "Crown" bars the price keeps firm at 14*l.* 10*s.* per ton.

Scotch Pig-Iron Trade.—The makers of Scotch pig-iron are particularly busy just now, hematite especially being in great request, the bulk of the output, as has been the case for some time now, being rapidly absorbed in the district. Very little is available for export, so long as Government retains the supreme control of all that is manufactured, and in every direction the price has strengthened within the past few days, and higher rates now rule. Home prices, of course, being controlled by Government, meantime remain stationary, and no change is expected in the immediate future.

New Ship Classification "Combine."—The British Corporation Registration of Shipping—an organisation established in Glasgow about a quarter of a century ago—has just entered into an agreement of an international character with an institution of a similar nature, the American Bureau of Shipping. Mr. Robert Clark, the chairman of the corporation, intimated, at the quarterly meeting held a few days since, that under the new arrangement the British Corporation will act for the American Bureau in the United Kingdom, and the American Bureau will in turn act for the British Corporation in America. Through the common adoption of the forthcoming new rules of the British Corporation the classification of the two societies will in effect be interchangeable, and although dual classification will not be easily obtainable, it will cost little more than single classification. In connection with the new "combine" several important appointments have been made, and every endeavour will be made to preserve the best interests of maritime affairs, both in this country and in America.

Martell Scholarship in Naval Architecture.—A scholarship designated the "Martell Scholarship in Naval Architecture" will be offered for competition by the council of the Institution of Naval Architects, who have been appointed administrators of the fund available for providing the scholarship. The scholarship is of the annual value of 100*l.*, and, subject to the conditions named below, is tenable for three years:—(1) Candidates for the scholarship must forward a written application to the secretary of the Institution of Naval Architects, 5, Adelphi-terrace, London, W.C., to reach him not later than January 15, 1917. (2) Candidates are not to be less than 18 nor more than 21 years of age on March 1, 1917, and must at that date have been continuously employed for at least two years upon naval architecture or marine engineering. (3) The scholarship will be awarded in connection with the competitive examinations for scholarships, studentships, &c., to be held by the Board of Education in May and June, 1917, in the following subjects:—(1) naval architecture; (2) pure mathematics; (3) applied mechanics (materials and structures); (4) either (*a*) applied mechanics (machines and hydraulics), or (*b*) heat engines. For information as to the exact dates of these examinations and particulars regarding them application should be made at once to the Board of Education, Whitehall, London, S.W. Candidates residing in Scotland or Ireland should apply for information as to the examinations to the Scotch Education Department, Whitehall, London, S.W., or to the Department of Agriculture and Technical Instruction, Upper Merrion-street, Dublin, respectively. Detailed syllabuses of the subjects of examination are contained in the volume of "Regulations and Syllabuses for Examinations in Science and Technology, 1915" (Rules 104), published by the Board of Education, which will continue in force for 1917 so far as regards the higher examinations. The lower examinations hitherto conducted by the Board have now been discontinued.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position has not undergone much alteration during the week, except for a little tightening up in supplies. Works, railways, blast-furnaces, &c., are not able to obtain their requirements with the same measure of freedom as they were until recently. This is due to two causes. Collieries are not working with the same regularity, whilst the state of the transport service is unsatisfactory, particularly with regard to empty wagons. This creates delays of a serious character, and supplies are even held up at pits owing to the non-arrival of wagons. All classes of manufacturing fuel are in big demand. Steam coal is wanted in heavy quantities both for home and export. Steam nuts are a short supply, and cobbles are none too plentiful. Slacks are an improved market. Gas companies are taking the maximum quantities on their contracts, and this strengthens the house coal position. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—Output is maintained in a progressive manner, and there is no falling-off in activity at all the Sheffield works. It is estimated that if the volume of production is continued at the present level up to the end of the year, 1916 will easily establish a record for the city, eclipsing in no unmistakable fashion the aggregate for the preceding 12 months. In 1917 new resources in the shape of additional plant and works will be available, so there is every prospect of even finer achievements in the future. The colossal output is placing a heavy drain upon the material market, and the consumption of all qualities of hematites is particularly heavy. Happily there are ample supplies coming forward. The common iron market has many irregular features. Both Lincolnshire and Derbyshire forge and foundry iron are hardly inquired for in certain cases, and yet some makers are able to dispose of the whole of their stocks at the maximum prices with the minimum of difficulty. Basic iron is in big request, and the production is being expanded. The light iron foundries, with few exceptions, are quiet, but the reverse is the case in the heavy foundries. The Swedish position is again in an unsatisfactory state so far as English buyers are concerned, for the prices all round are almost prohibitive. Fortunately, large stocks have been accumulated in the city in the past, and there is no present danger of shortage. American imports of billets are not heavy, but the quality is of a much higher standard than other recent deliveries. High-speed steel manufacturers find a ready demand for all they can supply, even though electric smelting has enlarged and improved the production to an altogether unexpected degree. Saw and file makers are busy. The cutlery trade has just entered upon an epoch-making period for, after many conferences and deliberations, the manufacturers have at last obtained the consent of the men to an agreement which will enable machinery to supplant much of the present hand labour. The union interests are safeguarded in the agreement, and the manufacturers are now regarding possible foreign after-war competition with equanimity. They have had a severe task to secure the introduction of the more up-to-date methods, and, having won, they are now considering more progressive ventures. The Admiralty are placing contracts for 50,000 plated spoons and forks, and a large number of plated-handle table knives. The overseas business of the city maintains a good figure with orders for tools, sheep shears, garden shears, agricultural implements, plane irons, steel, cutlery and plate.

PERSONAL.—The Paterson Engineering Company, Limited, of India House, Kingsway, London, W.C., have removed to Windsor House, Kingsway, for the duration of the war. Their new telephone number is Gerrard 6560.—The American Steel Export Company of the Woolworth Building, New York, has established a separate branch office in Pittsburg, under the direction of one of the Home Office staff.

THE UNIVERSITY OF HONG KONG.—We have received a copy of the new calendar of the University of Hong Kong. This institution was founded in accordance with a suggestion made by Sir Frederick Lugard in 1907, and has been generously supported by the Chinese business community as well as by a number of patriotic British firms. There are at present three faculties, viz., those of medicine, engineering and arts. Professor C. A. M. Smith, M.I.M.E., is the dean of the faculty of engineering, and has organised well-equipped mechanical laboratories.

GUNS FOR UNITED STATES BATTLESHIPS.—It is expected, says *The Marine Journal*, New York, that superdreadnoughts to be built for the United States Navy will carry main batteries of twelve 16-in. guns, as against eight such guns to be placed on the ships for which bids were opened last month. There is a decided sentiment among the members of the general board for a radical increase in the size of battleships, so that greater gun-power may be made possible. In order to carry 12 such guns, a displacement of probably 38,000 tons will be necessary. The new ships to be laid down next year will displace only about 32,000 tons.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Most home consumers of Cleveland pig-iron have made arrangements for adequate supplies to the end of the year, and consequently are not keen buyers at present. A few contracts for spring delivery are reported, but makers are very cautious in their dealings beyond the end of the year, and will not commit themselves ahead to any extent. Sales to Scotland show a falling-off somewhat. It is gratifying to learn of a growing tendency on the part of Cleveland pig-iron users to take up larger supplies of forge iron to mix with superior kinds, as No. 4 forge is relatively quite plentiful. Substantial inquiries on behalf of the Allies are reported, but beyond the current official allotments little iron is available for sale to France and Italy, and licences for shipment of new sales are granted very sparingly. Occasional small odd lots of Cleveland pig are sold to neutral countries, but such transactions occur only under very exceptional circumstances. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; whilst for shipment to the Allies, No. 3 is 98*s.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutrals, the minimum quotations are 105*s.* for No. 3 and 110*s.* for No. 1.

Hematite Iron.—There is rather more business passing in East Coast hematite iron. Very little, indeed, is purchasable for early delivery, but makers are much more disposed than they have been to give favourable consideration to inquiries on forward account, and rather substantial negotiations are proceeding for contracts over periods next year. In the meantime, the requirements of both home users and the Allies are adequately met by running contracts. Nos. 1, 2 and 3 are quoted 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Production of Pig-Iron.—The output of pig-iron promises to be increased this week-end by the restarting of a furnace by Messrs. Bolckow, Vaughan and Co., for the manufacture of Cleveland pig. This will bring the total number of blast-furnaces in operation on the North-East Coast up to 74, of which 29 will be making Cleveland pig, 31 producing hematite, and 14 manufacturing special kinds of iron.

Stocks and Shipments of Pig-Iron.—The stock of Cleveland pig-iron in the public warrant stores remains at 4,173 tons—4,137 tons of No. 3 and 36 tons of standard iron—there having been no change recorded since November 20. Shipments of pig-iron from the port of Middlesbrough during November are estimated at 30,000 tons, as compared with 53,610 tons for the previous month and 48,036 tons for November last year.

Foreign Ore.—Supplies of foreign ore are coming to hand in larger quantities, and imports for December promise to be on a rather large scale. Unloadings at Middlesbrough during November amount to 130,000 tons.

Coke.—Demand for coke for local consumption continues heavy, and values of qualities required are well maintained, though supply is very ample. Average blast-furnace kinds are 28*s.* at the ovens, and 30*s.* 6*d.* at the ovens is still named for low phosphorus sorts.

Manufactured Iron and Steel.—Government work monopolises most of the time of finished iron and steel producers, but very considerable quantities of mercantile shipbuilding material are also being turned out. Prices all round are steady and strong. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*—all for home use. For export, common iron bars are quoted 15*l.* and steel ship plates 13*l.* 10*s.* to 18*l.*, according to diameter.

"DAILY MAIL" YEAR BOOK, 1917.—We have received a copy of this year book, which is issued by Associated Newspapers, Limited, Carmelite House, London, E.C., at the price of 7*d.* net. It covers over 280 pages of original articles on the war, statistical data, commercial information, biographies, &c. Like the preceding editions, it will be found an admirable reference book on practically every possible subject.

THE LATE CAPTAIN W. H. JAQUES, U.S. NAVY.—Captain William Henry Jaques, of Hadley Wood, an American naval expert, has been killed on the railway near London. He was born in Philadelphia in 1848. During his active service in the United States Navy he served on many large ships and had charge of various important scientific works. He introduced into the United States the system of fluid compression and hydraulic forging of heavy masses of steel, and was the inventor of many improvements in the manufacture of heavy ordnance and arms. He was for some time associated with Captain John Ericsson in the development of submarine artillery. About the year 1888 he accepted a position with the Bethlehem Iron Company, now the Bethlehem Steel Company. In 1897 Captain Jaques undertook the development of submarine torpedo boats, and had been the president of the Holland Submarine Boat Company.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Only a limited business has been passing in the steam coal trade. The tonnage position has been a little more satisfactory, but vessels have still not arrived sufficiently freely to render colliery owners independent; stocks of coal have continued excessive, and buyers able to take quick delivery have readily secured concessions from quoted prices. For later December loading, however, values have been maintained with firmness. The best Admiralty large steam coal has been, to some extent, nominal; secondary descriptions have made 29*s.* to 30*s.*; Monmouthshire Black Veins, 29*s.* to 30*s.*; ordinary Western Valleys, 28*s.* to 29*s.*; Eastern Valleys, 26*s.* to 28*s.*; best bunker smalls, 18*s.* to 20*s.*; and cargo smalls, 12*s.* to 17*s.* per ton. In bituminous coal best households have made 25*s.* 6*d.* to 26*s.* 6*d.* at the pits; No. 3 Rhondda large, 29*s.* to 30*s.*; smalls, 22*s.* to 24*s.*; No. 2 Rhondda large, 26*s.* to 27*s.*; and No. 3 smalls, 18*s.* to 19*s.* per ton. The latest quotation for patent fuel has been 37*s.* 6*d.* to 40*s.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.* per ton.

Western Trade Matters.—The Court of Appeal has given judgment in the case of the Taff Vale Railway Company *v.* the Cardiff Railway Company. The plaintiffs lodged their appeal to prevent the defendants from putting an easement over certain of their lands in the parish of Pontypridd, where the two companies have a junction known as Treforest Junction. The Master of the Rolls, in announcing the decision of the Court, said he thought a notice to treat which had been given was bad, and that the Cardiff Company had no right to compel the Taff Vale Company to sell. He was of opinion, accordingly, that the appeal should be allowed with costs.—The directors of the Newport Abercarn Black Vein Steam Coal Company, Limited, recommend interim dividends for the half-year ended September 30 at the rate of 7 per cent. per annum upon the preference shares and 7½ per cent. per annum upon the ordinary shares; both dividends are to be paid January 1.—A local firm and one of its directors have between them decided to contribute 10,000*l.* for the endowment of a chair of metallurgy at Swansea Technical College. The names of the donors have not at present been officially announced, but Baldwin's, Limited, are spoken of.—Lord Rhondda and five of the directors of North's Navigation Collieries have visited Maesteg and inspected the collieries. When they entered the winding-engine house at Coegnant, the driver, John Rees, waved his cap and called for cheers. Lord Rhondda had a chat with Rees, and the result of the conversation was that his lordship gave a cheque for 50*l.* to assist the funds of the chapel which Rees attended.—A steel shelter-deck steamer, building at Sunderland, 7,800 tons deadweight, has been sold to Cardiff buyers for 200,000*l.*—The Main Colliery Company, Limited, has decided to split its 10*l.* shares into 1*l.* shares—ten new shares for each old share.—Lord Rhondda, speaking at Ferndale, said it had been remarked that in the old days employers were in closer touch with their workpeople than they were now, and that their relations were more friendly in consequence. No doubt a great change had taken place, and yet employers and employed got on very well now. He represented Merthyr, for instance, for nearly a quarter of a century, and was placed at the head of the poll with record majorities each time; whenever he appealed, in fact, to workmen, they had never shown him suspicion or hatred. Ferndale had given him Mr. Edgar Evans as a chemist. Mr. Evans had intellect and capacity, and more would be heard of him. The coal trade had not reached at present the zenith of its prosperity, and he believed that there would be great developments in the industry.—Owing to continued illness, Mr. W. J. Orders retired from business as from October 31. The partners in the firm of Orders and Handford, the managers of the Orders and Handford Steamship Company, Limited, will be Mr. T. J. Handford, Mr. J. Cory and Mr. J. Herbert Cory, and the business will be carried on as hitherto.—In connection with the high French prices limitation scheme, it is stated that since August 1 shipping to the amount of 300,000 tons has been lost, but that in the same period 335,000 tons of fresh tonnage have been provided, so that on balance there has been some little improvement in the situation; a more favourable change would, however, still be welcome.—The Stella Shipping Company, Limited, has decided to increase its share capital to 75,000*l.*; warrants for a final dividend of 1*s.* per share for the past year, making 20 per cent. for the twelve months, were posted on Monday.—Messrs. Radcliffe and Company, Cardiff, have purchased two steamers now under construction. Messrs. Radcliffe now control a fleet of nearly 30 steamers, representing upwards of 200,000 tons deadweight capacity.

EXTENSION OF GERMAN STEEL WORKS.—A number of important extensions are in course of progress as regards the large Becker steel works at Willich, which, it may be remembered, declared a dividend of 30 per cent. for the year ended June 30, against 25 per cent. for the previous year. A large site has been secured at Krefeld, immediately against the harbour and the Rhine. The harbour works and the construction of buildings and plant are being pushed ahead with all speed. This applies more especially to the steel works, which are not to wait for the completion of the blast-furnaces. Construction on the Willich works is also being hastened. The Reinickendorf works at Berlin are about ready, and will be used for the manufacture of entirely new specialities. The Fesca concern at Reinickendorf has been purchased on favourable terms.

POWER-FORGING OF CHAIN CABLES.

(*For Description, see Page* 541.)

FIG. 1. Hand-Welded Triplet No. 2, Open-Link Chain. Note Irregularities of Shape and Rough Appearance.

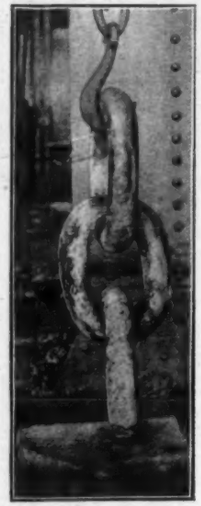


FIG. 2. Hand-Welded Triplet No. 2, Open-Link Chain. Revolved 90 deg. from Fig. 1, to show Irregular Shape of Middle Link.

FIG. 3. Hand-Welded Triplet No. 2, Open-Link Chain. After Test to Destruction. Note Lifeless Appearance. Broke at 364,000 lb. 525,000 lb. Required.

FIG. 4. Hand-Welded Triplet No. 1, Stud-Link Chain. Rough and Irregular.

FIG. 5. Hand-Welded Triplet No. 1, Stud-Link Chain. Tested to Destruction. Broke at 390,000 lb. 525,000 lb. Required.

FIG. 6. Power-Welded Triplet No. 3, Open-Link Chain. Smooth-Forged, Regular in Shape.

FIG. 7. Power-Welded Triplet No. 3, Open-Link Chain. Tested to Destruction. Looks Tough and Well Put Together. Broke at 532,000 lb. 525,000 lb. Required. It exceeded the Requirement for Stud-Link Chain.

FIG. 8. 3¼-in. Test Triplet. This Chain weighs 595 lb. per Fathom, and runs 6 links per Fathom. Ultimate Strength 612,000 lb. For Battleships of the Pennsylvania Class.

FIG. 9. 3¼-in. Test Triplet. Revolved 90 deg. from Fig. 8. This Chain weighs 595 lb. per Fathom, and runs 6 links per Fathom. Ultimate Strength 612,000 lb. For Battleships of the Pennsylvania Class.

FIG. 10. Shearing Bars into Bolts.

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page 522.*)

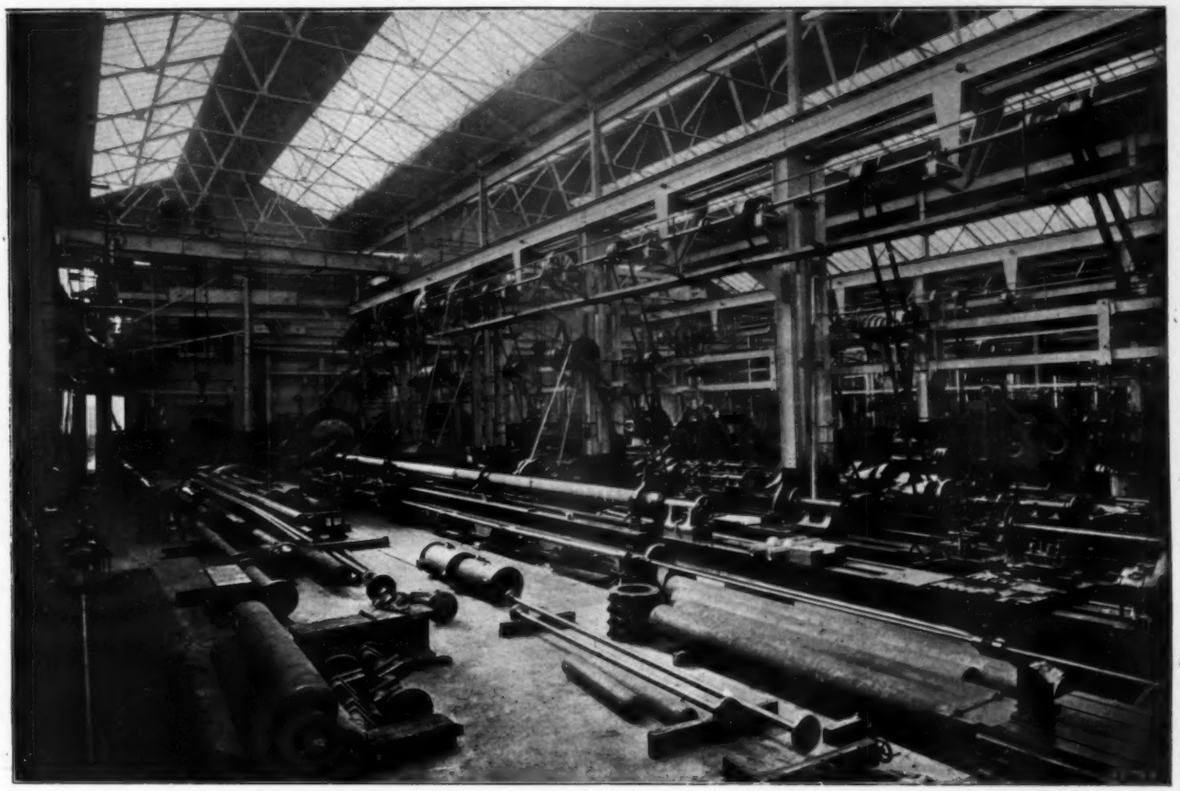


Fig. 47. View in the "D" Machine Shop at the Works of Messrs. J. Samuel White and Co., Limited, East Cowes.

Fig. 48. View in the "C" Machine Shop at the Works of Messrs. J. Samuel White and Co., Limited, East Cowes.

(*To face page 524.*)

THE ARRANGEMENT OF MACHINE SHOPS; MACHINE SHOPS AT THE WO

(For Descriptio Pa

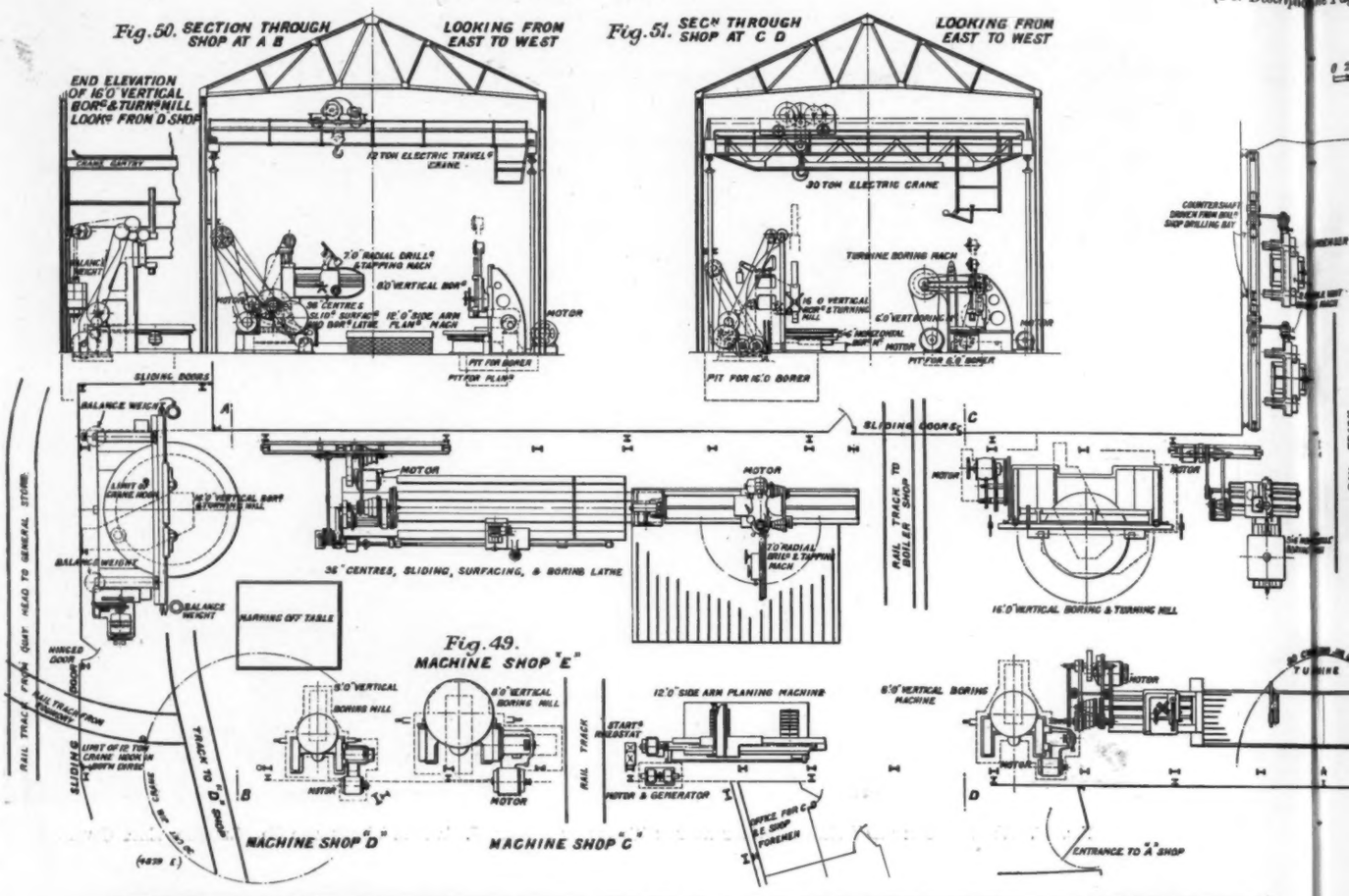


Fig. 50. SECTION THROUGH SHOP AT A B
LOOKING FROM EAST TO WEST
Fig. 51. SECN THROUGH SHOP AT C D
LOOKING FROM EAST TO WEST
END ELEVATION OF 16'0" VERTICAL BORG & TURNG MILL LOOKG FROM D SHOP
12 TON ELECTRIC TRAVELG CRANE
30 TON ELECTRIC CRANE
7'0" RADIAL DRILLG & TAPPING MACH
6'0" VERTICAL BORG
36" CENTRES LOOSE SURFACE AND BORG LATHE
12'0" SIDE ARM PLANG MACH
TURBINE BORING MACH
16'0" VERTICAL BORG & TURNG MILL
6'0" VERT BORING MACH
PIT FOR BORER
PIT FOR PLANG
PIT FOR 16'0" BORER
PIT FOR 6'0" BORER
SLIDING DOORS
BALANCE WEIGHT
MOTOR
36" CENTRES, SLIDING, SURFACING, & BORING LATHE
12'0" RADIAL DRILG & TAPPING MACH
RAIL TRACK TO BOILER SHOP
16'0" VERTICAL BORING & TURNING MILL
MARKING OFF TABLE
HINGED DOOR
RAIL TRACK FROM QUARRY HEAD TO GENERAL STORE
RAIL TRACK FROM QUARRY
LIMIT OF 10 TON CRANE HOOK IN NORTH BAY
TRACK TO "D" SHOP
Fig. 49.
MACHINE SHOP "E"
6'0" VERTICAL BORING MILL
12'0" SIDE ARM PLANING MACHINE
START & RHEOSTAT
MOTOR & GENERATOR
RAIL TRACK
6'0" VERTICAL BORING MACHINE
OFFICE FOR C.E. SHOP FOREMEN
MACHINE SHOP "D"
MACHINE SHOP "C"
ENTRANCE TO "A" SHOP

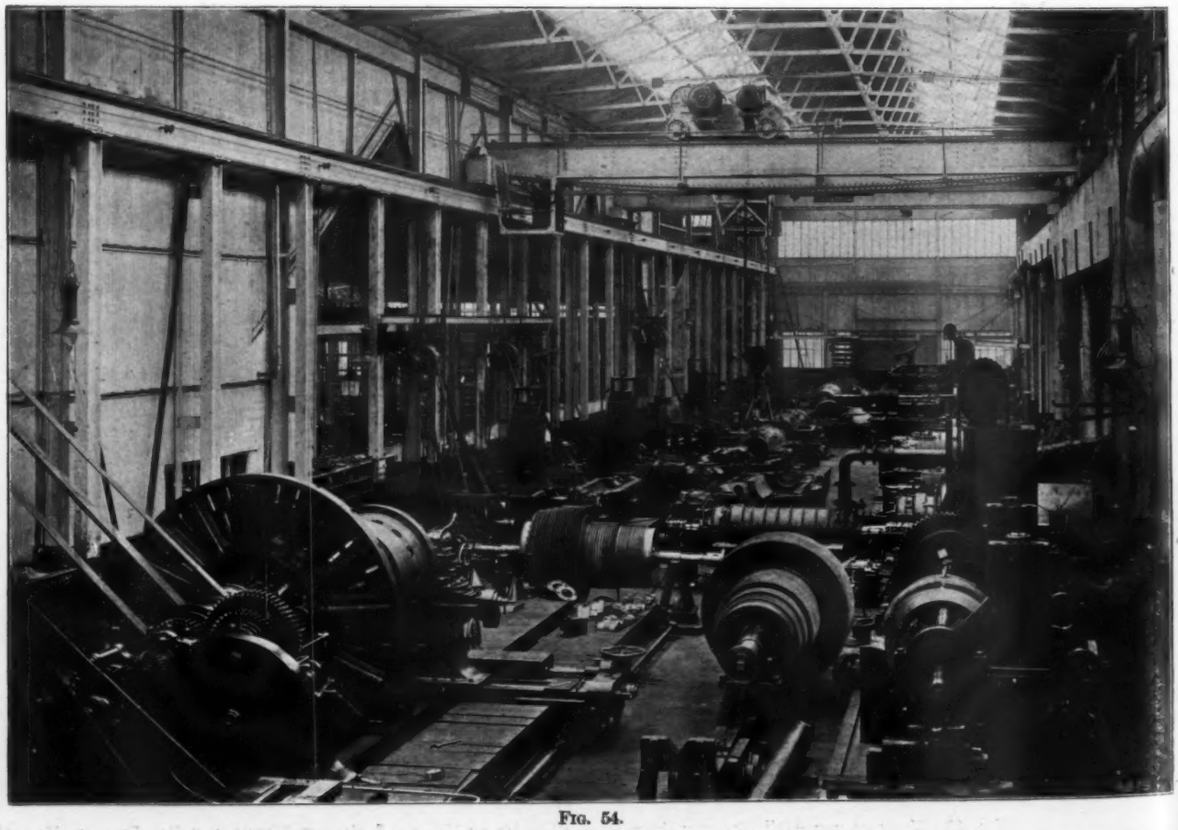
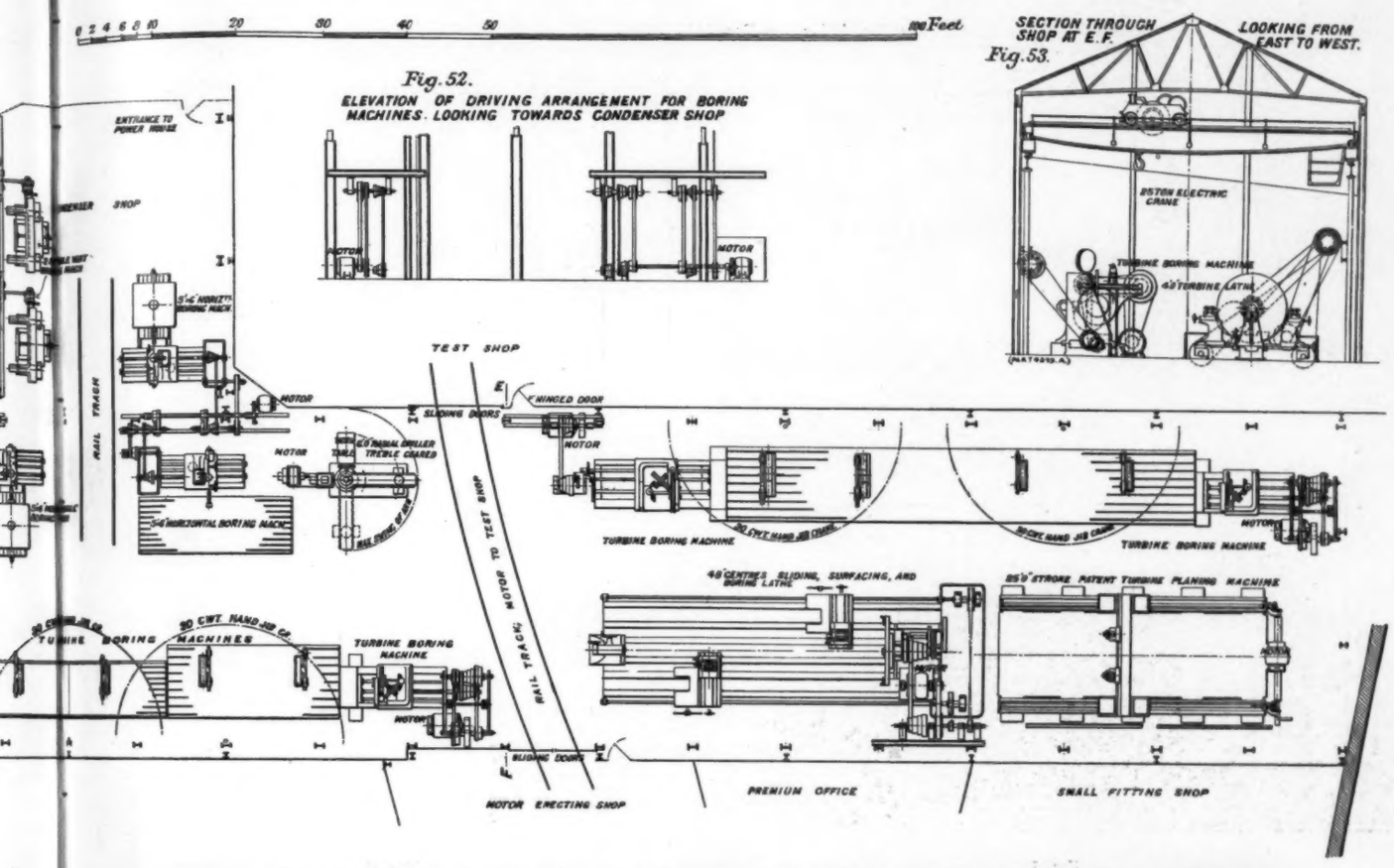


FIG. 54.

FIGS. 49 TO 55. PLAN, SECTIONAL ELEVATIONS AND PHOTOGRAPHS OF THE HEAVY MACHIN

THE WORKS OF MESSRS. J. SAMUEL WHITE AND CO., LTD., EAST COWES.

(Description Page 522.)



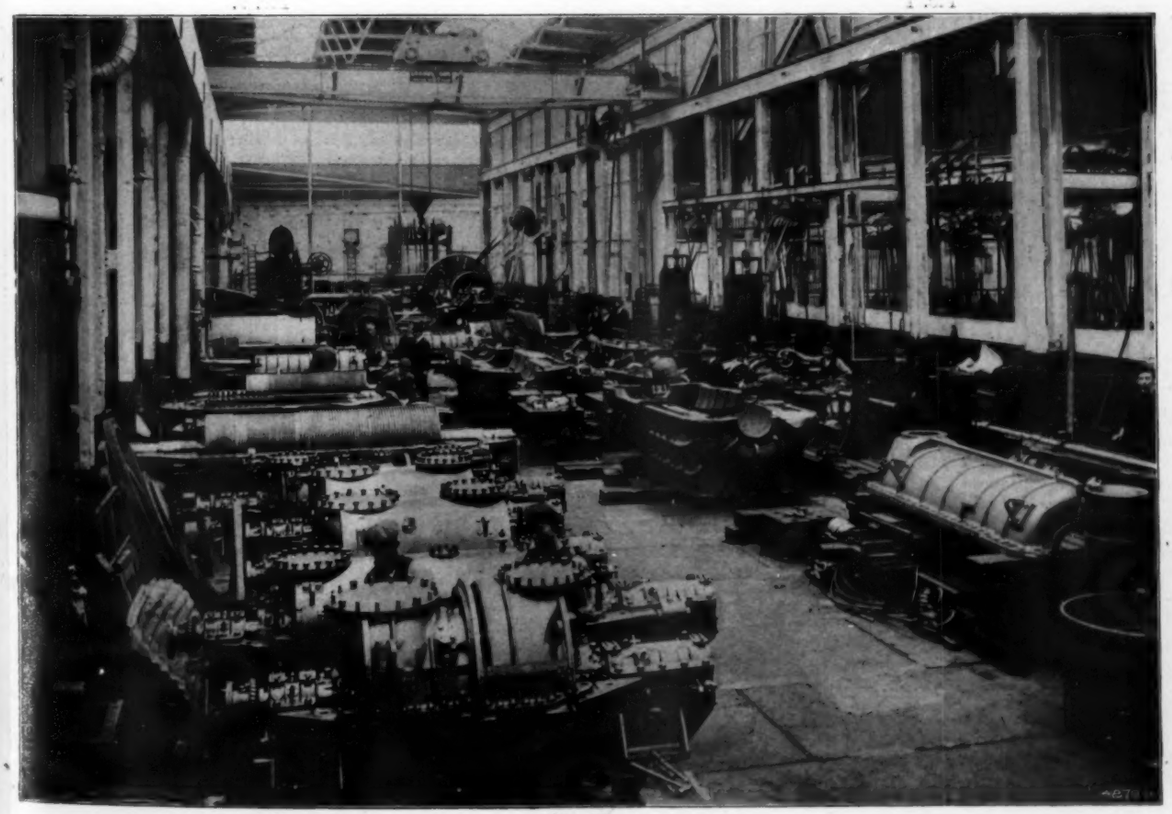


FIG. 55.

MACHINE SHOP "E" FOR DEALING WITH THE HEAVY PARTS OF STEAM TURBINES AND CONDENSERS.

MACHINES FOR MILLING SCREW THREADS.

CONSTRUCTED BY MESSRS. J. ARCHDALE AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

(For Description, see Page 525).

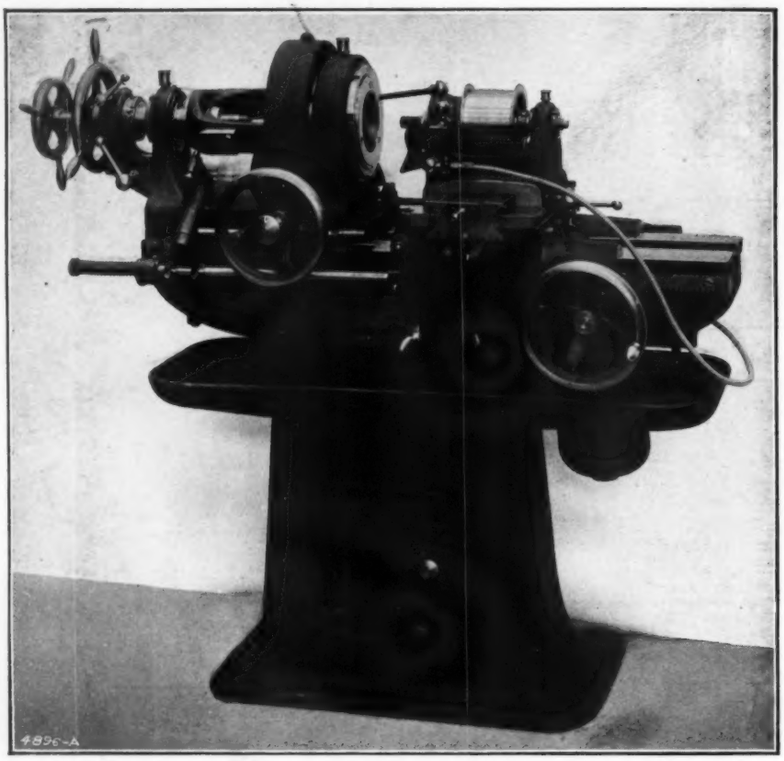


FIG. 1

FIG. 2.

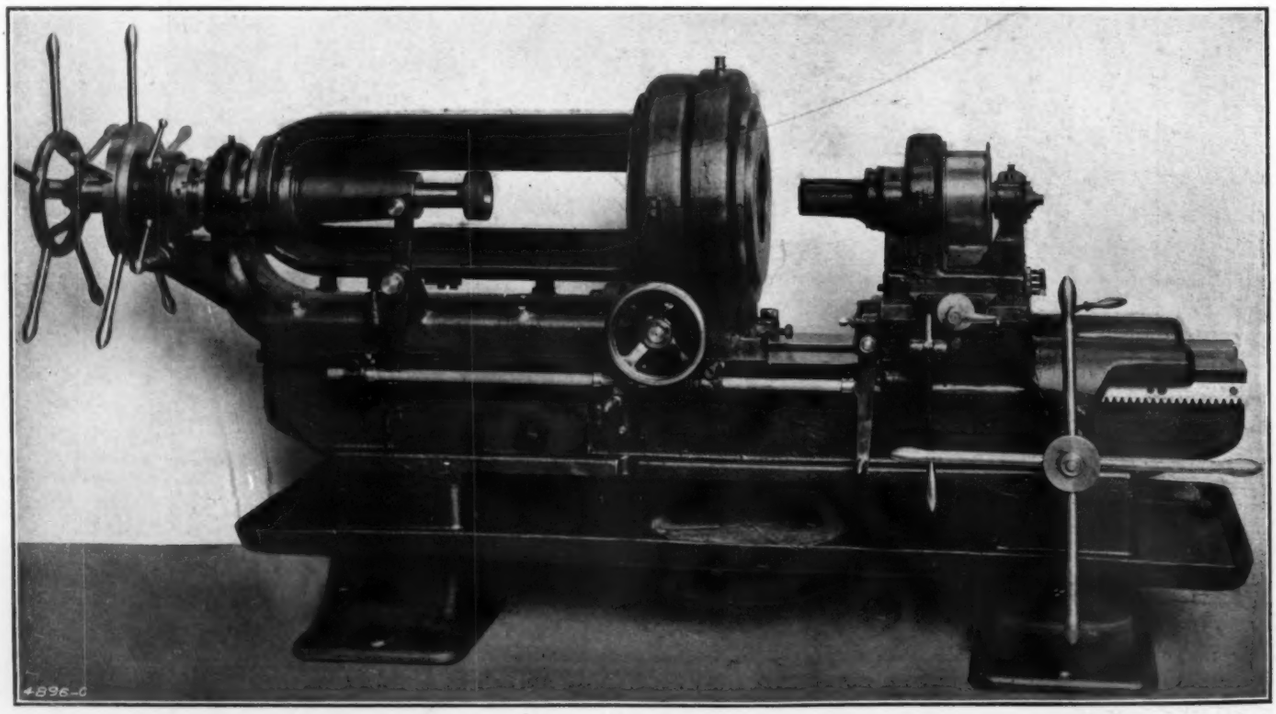


FIG. 3.

(To face page 525.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8596 GERRARD.

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With One Two-Page Plate and One One-Page Plate of the ARRANGEMENT OF MACHINE SHOPS, and One One-Page Plate of MACHINES FOR MILLING SCREW-THREADS.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 1, at 7.30 p.m., to meet the wishes of members in the Sheffield district, a meeting of the Institution of Mechanical Engineers will be held in the Mappin Hall, St. George's Square, Sheffield, for the presentation and further discussion of the "Report of the Hardness Tests Research Committee." Dr. T. E. Stanton, F.R.S., will explain the work of the Committee during the last two years, and will exhibit apparatus and specimens. Mr. J. Rossiter Hoyle, Vice-President, will preside.

THE ENGINEERS' CLUB, MANCHESTER.—Tuesday, December 5, at 7.30 p.m. Debate on "The Decimal System," opened by Mr. E. C. Barton.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 5, at 5.30 p.m. Paper to be further discussed: "Keadby Bridge," by Mr. James Benjamin Ball, M.Inst.C.E. Paper to be submitted for discussion: "Experiments on Earth Pressures," by Mr. Ponsonby Moore Crosthwaite, B.A.I., M.Inst.C.E. And ballot for new members.

THE RÖNTGEN SOCIETY.—Tuesday, December 5, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Paper on "Some Remarks upon Pastilles," by Dr. Levy and Mr. Stenning.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 6, at 7 p.m., at the University, Edmund Street. Mr. J. S. Peck, M.I.E.E., will read his paper entitled "The Parallel Operation of Electric Power Stations."

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, December 7, at 3.30 p.m., at the University, St. George's Square, Sheffield. The following paper will be read:—"Some Causes of Decay of Timber in Mines," by Mr. J. Mitchell, F.L.S., of the Imperial College of Science, South Kensington. Professor W. G. Fearnsides, M.A., F.G.S., will give a discourse on "Refractory Materials in the South Yorkshire Coalfield" (Fireclays, Ganisters, Dolomites, &c.).

THE INSTITUTION OF WATER ENGINEERS.—Friday, December 8, commencing at 2.45 p.m., at the apartments of the Geological Society, Burlington House, W. The following papers will be read and discussed:—"The Cross Hill Covered Service Reservoir for the Birkenhead Corporation," by Mr. W. J. E. Binnie, M.Inst.C.E., B.A. Cantab. "The Rating of Waterworks," by Mr. Charles Clifton, P.A.S.I.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Saturday, December 9, at 2.30 p.m., at Caxton Hall, Westminster. A paper will be read and discussed on "Locomotive Fire-Boxes," by Mr. Smith Mannering, Member, Brighton, Chief Boiler Inspector, London, Brighton and South Coast Railway.

THE ROYAL SOCIETY OF ARTS.—Monday, December 4, at 5 p.m. Howard Lecture: "Coal and its Economic Utilisation," by Professor John S. S. Brame, Royal Naval College, Greenwich. (Lecture II.) Wednesday, December 6, at 4.30 p.m. Ordinary meeting: "The Coal-Tar Colour Industry," by Mr. C. M. Whittaker, B.Sc. Sir William A. Tilden, D.Sc., Sc.D., LL.D., F.R.S., F.C.S., F.I.C., will preside.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 1, 1916.

STANDARDISATION AND THE URGENT NEED FOR MERCHANT SHIPS.

A GREAT deal has been said and written recently regarding the advantages to be gained by the standardisation of ship and engine construction—cheapness and rapidity of construction being the chief advantages claimed by the advocates of the system. In view of the large number of merchant ships transferred from their usual trade routes to the Government service, the recent losses of British and foreign-owned merchant ships due to the risks incidental to war time, and the urgent and ever-growing need for new tonnage not only to make good these losses, but also by increasing the tonnage available for the import of foodstuffs and the export of manufactured goods to provide at least a partial solution of the serious problem of rising food prices, it becomes imperative that steps be taken to ensure the most rapid and economical building of vessels to replace those lost or withdrawn from trade. To Mr. W. L. Hichens, the chairman of Messrs. Cammell, Laird and Co., belongs the credit for having put forward the suggestion that the solution of the present merchant shipping problem should be placed in the hands of a specially appointed Board of Shipbuilding Control composed of representatives of the Admiralty, Board of Trade, shipowners and shipbuilders. The chief functions of this Board would be:—(1) To place all orders for merchant ships and to ensure the maximum output and efficiency of all shipbuilding yards; (2) to consider the question of standardisation of vessels; (3) to subsidise the building of ships for private owners, or to put forward a policy of State-owned merchant vessels; and (4) to deal with the completion and disposal of merchant ships in course of construction for neutral countries.

The extent of the shortage to be made good, the need for the exercise of the most rigid economy in expenditure, and the rapidity with which the work must be turned out, are factors which make the application of the principle of standardisation peculiarly appropriate to the present situation. Of the truth of the general proposition that time and money can be saved on the manufacture of the second and all subsequent articles manufactured by one firm on standard lines there can be no doubt, and this fact is in itself ample justification for the immediate application of the standardisation principle to ship construction on a scale larger and more complete than has yet been attempted.

There can be no doubt that the adoption of a standard design of hull would have numerous advantages regarded from the constructional point of view. A system of "internal" standardisation could be adopted whereby each plate and angle in one ship would, as far as practicable, be a duplicate of each other plate and angle in the same or similar parts of the same ship. Decks, shell plating, tank-top plating, bulkheads, &c., could to a very large extent be designed on this principle, and by thus carrying the principle of standardisation to its logical limits an appreciable gain would be made in the time required to manufacture the raw material as well as in the time and cost of working material in the ship. The bending of frames for several ships at one time would enable the time and cost of bending and fixing the set iron round which each frame is bent to be distributed over the number of ships worked, and with two or three squads bending each a portion of the frames very rapid progress could be made. In the case of districts where the yards are situated close together and transport facilities are good it might be of advantage for one firm to bend frames for two or three yards building similar ships. In many cases the same templates could be used for marking off a number of plates and angles for repeat ships, as well as for one ship, while the machines would be set for and continuously employed on the one class of work, thus avoiding the loss of time involved in resetting them for different classes of work. Repetition work in marking off and in machine operations affords an opportunity for the employment of women, thereby releasing men for work of a more skilled nature.

The adoption of standard types of propelling machinery also would enable one set of patterns to be used for a large number of castings, would ensure more rapid construction and delivery of auxiliary machinery, and would largely increase and cheapen the turning out of work by machine tools in the shops by affording opportunities for the employment of special devices for the production of particular details.

At present many of our most important shipbuilding yards are building both war and merchant vessels—the latter being in many cases of the passenger or cargo-passenger type and by no means the most suitable for present urgent requirements—and progress on the merchant work is necessarily slow owing to the demands for men for urgent Admiralty work and the insufficient supply of labour. The types of vessel most urgently required would be a matter for special consideration by experts, the nature of the cargo to be carried, the cargo-handling equipment available at the trading ports, and various other points bearing upon the work of the ships in service being considered in conjunction with the most suitable dimensions for rapid and economical building and running. In this connection it is worth noting that large numbers of the most modern cargo vessels of various types now on Government service might be employed to better advantage in carrying cargo if suitable tonnage were available for the Government service, and it might therefore be an advantage to build standard vessels for the Government service and thereby release the cargo carriers now on war service. In a general way it would seem that vessels to carry coal, oil in bulk, grain in bulk, refrigerated meat, and general cargo should at once be standardised and the building put in hand.

The maximum benefit to the country will only be assured when the available building resources are co-ordinated and efficiently organised to that end, and this can only be done with the assistance of the Government. The first step would be the election of firms to build standard merchant ships

of one type only, and such firms should be allowed to build no other type of vessel while engaged on standard vessels. By confining firms to the building of one type only, the advantages gained by the employment of machinery on one class of work would be supplemented by increased efficiency of men and foremen due to familiarity with the details of construction, and a smaller number of skilled men would be required to carry on the work. This would ensure the maximum output for men and machines and would be of especial value in saving time and labour in the construction of propelling machinery.

A committee on the lines suggested by Mr. Hichens would decide upon the types of vessels most suitable for meeting the present urgent needs, the number of each type required, and the essential features of standard designs for each type. The preparation of working drawings and other data required for the construction of each type would be undertaken by selected firms of shipbuilders and engineers under the supervision of competent overseers appointed by the committee, and the material ordered for the number of vessels decided upon. Delivery of raw material from the steel works, foundries, &c., also auxiliary machinery, steam pipes, &c., would be arranged for in the necessary rotation by the committee and guaranteed by the Government. The provision of an adequate supply of skilled labour would also come within the province of the committee. Under conditions such as above outlined, and with the whole of the resources of the selected yards and engine works devoted each to one type of vessel and propelling machinery respectively, the maximum benefit of standardisation would be added to the benefits which the nation would derive from the additions thus made to the merchant service.

The question of whether these vessels should be built for and run by the Government or the recognised shipping companies, and, if the latter, whether under subsidy or other arrangement, would be considered and decided by the Board. There is much to recommend an arrangement whereby the vessels would be built for the Government and run by the large shipping companies under Government control. Such an arrangement would ensure the maximum speed of production, the application of all the provisions of the Munitions of War Acts as regards employees and working conditions, and would prevent the artificial inflation of freight rates for private gain.

PROGRESS WITH THE INTERNAL COMBUSTION ENGINE.

At a time when there is a tendency to appraise more truly the nation's position and scientific achievement, it is appropriate that such an authority as Dr. Dugald Clerk should establish the British right to credit for originative work in connection with the internal combustion engine, as indeed with all types of prime movers. Dr. Clerk is entitled to speak on this subject, because he has devoted forty years of his life to the improvement of the internal combustion engine, and has brought to bear, first on the invention and later on the development of this prime mover, great ingenuity, painstaking research and practical knowledge. As it has been generally accepted that most of the work of an original character has been done by Germany in connection with the internal combustion engine, Dr. Clark did well, in his paper at the Royal Society of Arts, on Wednesday, to point out, by formulating a record of early patents from 1791, that Germany occupies a position secondary at least to Britain, the first German patent being dated 1852. The important principle of compression before ignition, in order to provide an economical engine, expanding the gases of explosion in the most favourable manner and at the same time producing large power for small bulk, was the invention of an English engineer, so far back as 1838. The patent then taken out by Mr. William Barnett, as stated by Dr. Clerk, gave full particulars of such an engine, and established a claim to be the originator of both the compression idea in its present form and of the two-stroke cycle of operations. The first German engineer to appreciate the advantages of compression was Mr. Gustave Schmidt, and this he disclosed 23 years later in a paper read before the Society of German Engineers in 1861. Mr. Million, a Frenchman, showed also in the same year that he had exceedingly clear ideas of the advantages of compression. Mr. Alph. Beau de Rochas, also a Frenchman, in a pamphlet published in Paris in 1862 discussed what practically became later the Otto cycle. But it was not until 1876 that Dr. Otto overcame the difficulties and produced the first commercially successful gas engine utilising the principle of compression before ignition, which had first been proposed 38 years earlier by the British engineer Barnett.

No two-stroke engine of any power was constructed until 1879, when Dr. Clerk exhibited the first compression gas engine at the Kilburn Show of the Royal Agricultural Society of England. His patent had been taken out in the preceding year. In this engine air was compressed in a separate pump; but in Dr. Clerk's best-known engine, that patented in 1881, he carried into effect the proposal of Barnett of 1838 in compressing the air within the cylinder and giving one power impulse for each double stroke, but it differed in applying exhaust ports at the outer end of the stroke, over-run by the piston, to time exhaust and charging. It further differed in coupling the pump or displacer cylinder to the main crankshaft, instead of driving it at twice the number of revolutions by gear wheels.

In reference to the claims by Mr. James Robson, Dr. Clerk stated that when he was inventing, designing and experimenting with the two-stroke engine in Glasgow, Mr. Robson was busily at work on compression. Mr. Robson's first patent was dated 1877, No. 2,334. "It describes an engine of the non-compression type; but he produced a two-stroke engine with compression, under patents dated 1879 and 1880. Messrs. Tangye, of Birmingham, produced an engine with Mr. Robson, which was first exhibited in public by them at the end of 1880. In this engine the front end of the cylinder was enclosed and used as a pump to force a mixture of gas and air into a reservoir at a pressure of about 6 lb. per square inch above atmosphere; the piston over-ran ports in the cylinder, but the exhaust was not timed by it; a separate valve was used which controlled the exhaust. Siemens, in 1861, and Brayton, in 1873, had proposed constant-pressure engines, in which the front end of the cylinder was used to compress the charge, which was utilised on the other side of the piston to produce power by combustion and expression; but Robson was the first to propose the use of the front to lightly compress the charge for the compression engine of the explosion type." The two-stroke or impulse-per-revolution engine was thus the result of the work of the English engineer Barnett in 1838, the French engineer Million, and the German engineer Schmidt, in 1861, and British engineers Clerk and Robson—Clerk by his 1878 and 1881 engines, and Robson by his 1879 and 1880 engines. Dr. Clerk thus adjudicates on the rival claims:—"Mr. Robson's son, Mr. James Robson, of Messrs. Tangyes, Limited, published an interesting booklet last year, describing his father's early work, from which it appears that Robson experimented with gas engines of different types from the early date of 1855, and he rightly claims priority for his father as the inventor of one type of two-stroke engine—that in which all the pumping and motor actions are performed by one piston in a single cylinder."

While the two-stroke engine continues to be made, notably in Germany, the test of use and time, according to Dr. Clerk, has proved the four-cycle to be the best adapted for most purposes, and by far the largest number of internal combustion engines operate according to this cycle. Thus, in Germany 260,000 brake horse-power of four-stroke engines was produced in 1907 and 91,000 brake horse-power of two-stroke engines.

Referring to the later research work, Dr. Clerk showed that the English work on the nature of gaseous explosions, dealing with questions of varying specific heat, rate of heat loss to walls, effect of polished inner surfaces, radiation effect, and the discussions on dissociation, have proved of vital importance to the science of this subject. Most valuable work has also been done in France, while some American work has also been performed. Germany has carried out some investigations, principally at the Reichsanstalt at Berlin. "The German scientific work on this subject is much inferior in importance to the British . . . the German scientific men are behind in the theory of these motors, although their practical constructors have done excellent work, with even most erroneous ideas of the nature of the forces with which they are dealing." Dr. Clerk next dealt with the commercial development, referring to the work done by Crossley, Atkinson, Humphrey, Priestman, Tangye, Akroyd-Stuart, Hornsby, Dowson, Mond and Thwaite, the last named having done much in the utilisation of waste blast-furnace gases in engines. Regarding the work of Dr. Diesel, Dr. Clerk pointed out that the Diesel engine undoubtedly fulfils important purposes in both stationary and marine work, where oil can be had. "Although it has taken an important place, and will continue to keep an honourable position, its advocates have rather exaggerated its possibilities. The amount of oil in existence in the world is too small to allow of the future proposed by Diesel enthusiasts. For stationary purposes undoubtedly gaseous fuel prepared from coal or carbonaceous matter will maintain the leading position."

Dr. Clerk showed that even in manufacture the British position is superior to that of Germany. The impression that Germany is more advanced in the application of the internal combustion engine is due to the fact that they had devoted much more attention to the large-cylinder gas engine and oil engine than the British. Our engineers had never been satisfied with the existing line of development of these large-cylinder engines. They considered that the building of large engines, practically without modification of either the thermodynamic or operative cycle, was a costly mistake, leading to development in a wrong direction. They had devoted more attention to multi-cylinder engines than the Germans, as thereby they produced greater power for a given weight of metal utilised. The British engineers and scientific men were still convinced that other methods must be confined rather to increase in power than to mere increase in the dimensions of cylinders.

In the volume of horse-power turned out, the British total for the latest years when reliable figures were obtainable was shown to be three times that of Germany, the total for the former, including all types, being 1,528,962 h.p., as recorded in the first census of production, published in 1907. For the same year the total for Germany was 531,000 h.p. Of our total 680,177 h.p. was utilised in factories, and in stationary gas, oil and petrol engines, as compared with 351,000 h.p. in Germany. The agricultural engines of the internal combustion type in this country totalled 98,785 b.h.p. For motor cars and cycles there were then in use engines of 750,000 b.h.p., against the German total of 180,000, but no doubt the later figures show a great increase in both cases. In view, probably, of the immensely greater population, the total of internal combustion engine power for the United States is low—about 2,500,000, one-half of which is due to motor cars. The number of engines for stationary work in factories and mines was in 1909 1,299,021 b.h.p. The power of stationary engines in France is not available, but Dr. Clerk estimates that in 1909 the four countries named had engines aggregating 6,000,000 h.p., of the internal combustion design working with oil, petrol or other fuel. This is an enormous development for a comparatively new prime mover, but it falls very far short of the volume of work done by the steam engine. The proportion of total power due to internal combustion motors is in Britain between 6 and 7 per cent. and in America just over 4 per cent. The engines of the ships of the world have a power of about 24,000,000, a very small proportion of which are of the internal combustion type.

ENGINEERING SCHEMES IN PARLIAMENT.

Naturally under existing conditions the programme of proposed works of public utility to be submitted to the next session of Parliament is both modest in dimensions and humdrum in character. Indeed it is difficult to see how financial support

will be found even after the war for any very ambitious industrial ventures. With safe government and municipal stocks yielding something in the neighbourhood of 5 per cent. the inducements must be considerable to tempt capital to embark in speculations of the character to which the development of the country has been so much indebted in the past. The prospect is still less alluring to the investor in view of the *intransigeant* attitude of certain sections of organised labour in the recent past. It is to be hoped that the new conditions may modify this frame of mind considerably. In recent years both labour and capital have been too cheap for the ultimate good of either. What is easily and cheaply obtained is seldom valued at its real intrinsic worth.

Railways.

The South-Eastern and Chatham companies are again promoting a Bill to facilitate the strengthening of the Charing Cross bridge. A similar measure was rejected last year by the House of Commons, largely owing to the interested exertions of architects. The latter have long been anxious that the principal railway bridges over the Thames should be replaced by road bridges. New thoroughfares of first importance would thus be established, and architects would benefit largely by the consequent extensive building operations. So far as St. Paul's railway bridge is concerned crossing this has proved so valuable to the military during the past two years that a renewed attack on it is for long unlikely. The Charing Cross bridge, however, stands on a different footing. It is admittedly an unhandsome structure, but its utility is very considerable in giving direct and immediate access to, perhaps, the most conveniently situated railway station in London.

The transfer of this station to the other side of the river would not only be costly at the outset, but would involve a heavy tax for all time on the passengers landed there, of whom the vast majority would have to make their way by tram, bus or taxi to the northern bank. No doubt this prospect is in part responsible for the strength of the opposition to the proposals of the company, since there are many interests—tramways, omnibuses, taxis and tubes—which naturally are inclined to welcome any change, no matter how costly or inconvenient to the community at large, which will increase their receipts.

The opposition due to these two interested classes of adversary is assisted by that of the numerous body which in matters æsthetic wishes "to be on the side of the angels," at least so long as their personal interests are not concerned. In such technical matters as are involved in the considerations of safety, which were responsible for the inception of the company's scheme, they feel, even if they do not acknowledge, their ignorance, but in matters artistic everyone considers himself competent, or at least wishes to gain such reputation for good taste as may be derived by supporting those who profess to be experts in æsthetics. There is no doubt but that the company's proposals will greatly diminish the crude appearance of the structure as it at present exists, and were the principal opponents of the scheme entirely disinterested in their contentions they would undoubtedly welcome the Bill as tending to increase the amenities of the river.

The existing state of intensive production in the Manchester district is reflected in the considerable number of proposals for improved railway connections in the industrial areas. Thus the trustees to the will of Sir Humphrey de Trafford are promoting a Bill authorising the extension in Davyhulme of the branches connecting this area with the metals of the Cheshire Lines Committee. Messrs. Levinstein, Limited, have a Bill for a line to their Crumpsall Chemical Works from the Lancashire and Yorkshire Railway at Crescent-road Bridge. Again, Sir W. G. Armstrong, Whitworth and Co., Limited, seek powers to widen the existing branch at Stuart-street of the Manchester Corporation and to extend these lines to their works. The whole of the new system shall, it is proposed, be operated by the Lancashire and Yorkshire Railway Company.

It may also be mentioned that the Cheshire Lines Committee have a Bill authorising the enlargement of their Throstle's Nest Tunnel, an operation which will involve an interference with a main sewer belonging to the Manchester Corporation.

Light Railways, Tramways and Motor-Buses.

Very little tramway work of any kind is proposed, and none of great importance. The Trafford Park Company seek powers to construct new light railways in Davyhulme and Stretford, and the Blackpool Corporation have in prospect a number of minor lines and extensions. A purchase Bill is promoted by the Corporation of Ashton-under-Lyne, who seek to acquire the Oldham, Ashton-under-Lyne and Hyde and District electric tramways and to construct some new lines within their own borough.

Quite a number of the smaller local authorities in Wales are seeking powers to run motor-buses, a clause in the Bills providing for the leasing of the undertakings to companies or to other local authorities or to a joint board. The promoters in question are the urban district councils of Mynyddislwyn, Bedwas and Machen, Ebbw Vale and Caerphilly. The corporation of Ashton-under-Lyne is applying for similar powers, which in this case will include the right to operate the vehicles outside of the borough limits. The local authorities of the larger boroughs are, however, in general, hostile to motor-bus traffic. They have, in most cases, committed themselves to tramways, and fear adverse effect upon this speculation from newer and more efficient methods of passenger transport. Many of them, it is true, have taken powers to operate motor-buses on their own account, but whether these powers are to be effectively exercised remains to be seen. In the earlier years of electric lighting many boroughs owning gas works acquired provisional orders for electric lighting merely with a view to protect their gas undertakings and with no intention of exercising the powers acquired. In the early days of the motor-bus tramway authorities ridiculed the possibility of running such vehicles at a profit, and published detailed balance-sheets, which went to show that the running expenses were excessive. As Huxley pointed out years ago, however, it is impossible to forecast the future of any infant, and other arguments are now advanced in opposition to the new system. In the first place, it is asserted that to handle the morning and evening peak loads double as many buses must be provided as tramcars for the same traffic. This statement, which is probably an exaggeration, is followed by the *non sequitur* that the result would be intolerable congestion of the streets. According to the official report of the Board of Trade, if the obstruction caused by a tramcar be taken as 10, that due to a motor-bus is 3, so that even were it true that twice as many buses would be required as cars the congestion of the streets would be actually diminished. The other objection raised is that if motor-bus traffic be permitted the streets will require strengthening. This is probably true, but local authorities are surprisingly sanguine if they imagine that this eventuality can be indefinitely postponed. The increasing use of other types of motor vehicle will rapidly falsify any such anticipation.

Electricity.

The most notable feature of the applications for powers for the supply of electricity is that the Electrical Distribution Company of Yorkshire is seeking for Provisional Orders for Rawdon and Yeadon, Clayton and Queensbury, Penistone, Wortley, Otley, Garforth, Featherstone, Luddenden and Horbury. If this appeal is successful a substantial step will be taken towards remedying the disastrous conditions with which electrical undertakers were saddled in the infancy of the industry by Parliament and the Board of Trade. The main idea of our politicians at that date was to prevent the establishment of schemes of electric supply covering large areas and to favour the setting up of numerous isolated and competing plants. It is now recognised that large stations can practise economies which are not feasible at small, and the fewer the independent plants in any district the better for the community at large and for our manufacturing industries in particular.

The Sheffield Corporation are promoting a Bill authorising them to establish a new generating station on lands in the borough of Rotherham of which they are already the owners, having acquired them for their sewage disposal works. The area in question is known as the Blackburn meadows, and lies between the lines of the Great Central Railway Company and the River Don. Possibly it is intended to use the sewage as condensing water. The Ripon Corporation are demanding a Provisional Order for Ripon and Knaresborough, with powers to lease to other undertakers.

The South Metropolitan Electric Tramways and Lighting Company seek powers to supply Ewell and Cuddington. This proposal appears to conflict with a demand for somewhat similar powers made by the Corporation of Wimbledon.

Gas.

The only noticeable feature in connection with the applications made on behalf of gas undertakings is the Bill promoted by the South Staffordshire Mond Gas (Power and Heating) Company. This Bill will authorise an increase in the charges made for gas, and will vary or set aside existing contracts based on the old rates. This step has no doubt been forced on the company by the phenomenal rise in the cost of coal. The Gas Light and Coke Company have a Bill conferring on them further powers for the provision of ships and authorising an extension of their existing profit-sharing scheme. Bills for substituting calorific standards for the illuminating standards previously authorised, or for extending works or areas of supply, are promoted by the gas authorities at Stretford, Lea Bridge, Kenilworth, Haslemere, Sheffield, Tonbridge and Hemel Hempstead.

Water Supply.

The only water scheme of much importance is that for which powers are sought by the Corporation of Bolton, who propose to form impounding reservoirs in North-East Lancashire by dams across the Roeburn and the Hindburn rivers. Of the two reservoirs proposed on the Roeburn river one will be formed by a dam to be constructed in Roeburn dale at a point about 7 furlongs from the Mallow dale bridge. The other, across the same stream, will be in Mallow dale. Similarly, two reservoirs are to be formed on the Hindburn river, to be known respectively as the Hindburn and Swans reservoirs. To facilitate the works, powers are taken for laying down railways from Hornby station on the Midland Railway to the reservoir sites. The distance of these from Blackburn is about 40 miles. The Bristol Waterworks Company propose to take water from the River Yeo at Cheddar, a weir being constructed there across the stream. Subsidiary works include a new service reservoir at Rowberrow, and, what is of more importance, a complete sewerage scheme for the village of Cheddar. The intense industrial activity at Barrow and the consequent increase in the demand for water has led the Corporation of Barrow-in-Furness to apply for a removal of the present restrictions on the abstraction of water from the River Duddon. The Chepstow Water Company seek powers to construct new collecting chambers or reservoirs at Kilgwrrwg, Newchurch East, and at St. Arwan's Grange. The Rickmansworth Valley and Uxbridge Valley Water Company have a Bill extending their limits of supply in the rural districts of Amersham and of Watford, and to Hughenden.

Docks.

The Port of London Authority are asking powers to enlarge the Old Shadwell Basin and to extend and improve the West India Docks. The works will include a new entrance lock on the Thames, with a pier adjoining thereto. A dry dock is also to be constructed near the South Dock Basin and a new cut between the South Dock and Millwall Inner Dock.

THE LATE SIR HIRAM STEVENS MAXIM.

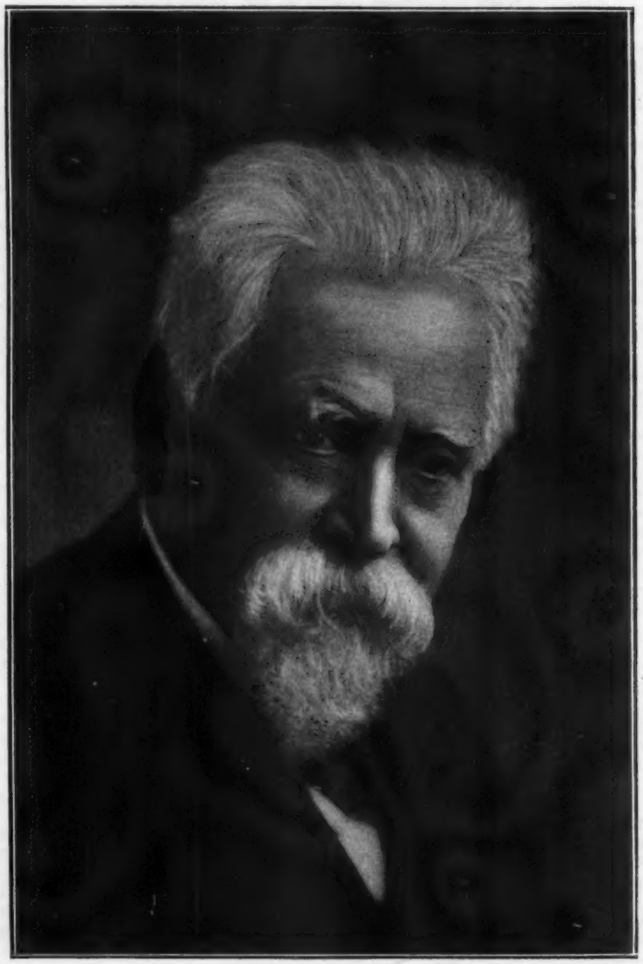
By the death of Sir Hiram Stevens Maxim, on the 24th inst., we have lost one of the great inventors of the nineteenth century. Of lowly parentage, imperfectly educated, and with no regular technical training, he, nevertheless, attained a very high position not only in one branch of engineering but

in many. He is, of course, most widely known by the invention of the machine gun which bears his name, and in the construction of that gun we can find a clue to the action of his mind in most of his work. There had been machine guns in plenty before his time. The French army was fully provided with them in the Franco-Prussian war, and great expectations were formed as to the execution they would effect. But the mitrailleuse was a disappointment, and as to the others, it was said that the British Army had never used a machine gun in action without it jamming. At the critical instant, when a stream of bullets was required to meet a charge, the gunners had to stop and dismantle their piece, or else to abandon it. Many capable engineers had applied themselves to the problem of a gun which should be both rapid and light. It was fairly easy to attain either characteristic. If the gun were worked slowly enough it would not jam, or if it were made heavy by using a multiplicity of barrels the same result could be attained. It was not that rapid fire for a single barrel was impossible; it could often be maintained for a considerable time, but sooner or later the jam came and the weapon was put out of action. When Maxim took up the subject he saw to the centre of the problem at once, recognising that the cartridges did not all explode at the same speed. Among the multitude of perfect cartridges there would be, once in 10,000 times, perhaps, a slow one, which after the impact of the striker would hang fire for a fraction of a second. But in that interval the machine had opened the breech and partly extracted the shell, with the result that the force of the explosion was expended on the mechanism instead of upon the bullet. Maxim saw that the remedy for this state of things was to make the explosion open the breech, and then it did not matter how long a cartridge might hang, the gun would wait its time. This discovery was representative of nearly all he did. He came with a mind free of preconceived ideas, and tearing aside all the outer circumstances of a case he went straight to the core, applying common-sense principles, which generally sufficed.

It must not be assumed that Maxim was an amateur mechanic who produced only ideas to be worked out by others. On the contrary, he was a skilled designer, and lavished great care on detail. In the case of the gun it was not possible to patent the broad principle, for it was found that some suggestion of it had been put on record previously, although nothing had been done to give it form. Maxim therefore had to pile patent upon patent to stop all the ways by which a breech block could be operated by the firing of a cartridge, and, as far as we know, no one was ever able to creep through the ring fence he erected around his original idea. He was, moreover, more fortunate than most inventors in his associates. While the idea was in embryo, before any complete drawings had been made, Maxim was introduced by Mr. Randolph R. Symon, the vice-president of the Mexican Central Railway, to Mr. Albert Vickers, who at once recognised the value of the invention. An arrangement was speedily made. Symon and Vickers found the money, and the three were to share the profits. The Maxim Gun Company, with Mr. Vickers as chairman, was formed in 1884, and in 1888 amalgamated with the Nordenfelt Company, becoming the Maxim-Nordenfelt Guns and Ammunition Company, with works at Erith. Later these were absorbed in the Vickers firm, which then became Vickers, Son and Maxim. In the meantime the Maxim gun had been supplied in large numbers to all the military powers of the world. It was adopted by the British Army in 1889, and by the Navy in 1892, and we have lately found to our cost how lavish was the equipment of it in the German Army.

No one of Mr. Maxim's inventions ever fascinated the public as did his gun. Means of killing one's fellow creatures have a strange attraction even in peace time, while in war they become of absorbing interest. But next to the gun in popular esteem came the Maxim flying machine. Not the glorified merry-go-round which has appeared as a side show at recent exhibitions, but the machine constructed in 1892-94 and tried at Baldwin's Park, Kent, in the latter year. This machine was a failure, inasmuch as it only made a few restrained flights between guides, and was then damaged. But it demonstrated the fact that it was possible to fly by steam, and in so doing it lifted aeronautics from an aspiration into an art. At that time the present writer explained in these columns that "at every point Mr. Maxim has been obliged to leave the beaten path of mechanics and find new paths. Indeed, the machine constitutes a perfect museum of inventions." One cannot help feeling, however, that in this instance Mr. Maxim allowed his enthusiasm as a mechanic to cloud the piercing common-sense with which he viewed every other problem. He had a flying machine, but he had no pilot to manage it, and indeed we can see, with our present knowledge, that it was quite unmanageable. The Wright Brothers tackled the job from the other end. They first learned to fly in gliders, and so acquired not only dexterity, but also a knowledge of the essential features of an aeroplane. When they had done this they applied mechanical power to their machine, and were no longer dependent on gravity.

Maxim is said to have spent 20,000*l.* over his machine, which was illustrated in our columns on August 10, 1894. The most novel features were the engines and boilers. It was clear from the beginning that only by a drastic reduction of weights could these elements be carried on an aeroplane. The weight of the boiler to give 300 h.p. was 1,200 lb., including casing, feed-water heater, dome and up-



From a Photograph by Elliott and Fry.

Hiram S. Maxim

take. The heating surface was 800 sq. ft., and the flame surface 30 sq. ft. The engines weighed 600 lb., so that the total weight of the motive power apparatus was 1,800 lb., or about 6 lb. per horse-power. This was certainly less per unit than the Wrights' engine, and indeed than any of the early aeroplane motors. But unfortunately the feed-water had to be carried, and this could not have been less than 6,000 lb. for an hour's trip, a quite impossible weight. Maxim considered the feasibility of an air condenser, but he never proceeded with it. He had already expended much time upon the preliminary experiments, especially in relation to the best form of screws and in determining the lifting power of aerofoils of various forms. A paper on this subject was read before the British Association in 1894, and reported in our issue of August 24 of that year.

We are accustomed to see a mechanic transfer his interest unconcernedly from one machine to another, but he generally draws back when faced with a chemical problem, feeling that his knowledge—or his instinct—will not avail him in that field. But Maxim seems to have had no misgivings of that kind. In his early experiments with electric glow-lamps he needed phosphoric anhydride to extract moisture from the gases. This could only be obtained from Germany at a high price, so he undertook its manufacture himself and rapidly developed a process which turned out this product at the rate of ½ lb. a minute. At a later date, on one of his gun trials, Sir Andrew Clark, Surveyor-General of Fortifications, mentioned to him that the Government were about to pay 35,000*l.* for the secret of the German slow-burning cocoa powder. Their chemists had been quite baffled by it, for its chemical composition was identical with that of gunpowder, yet it gave much less pressure in the gun, but sustained it so well that a greater muzzle velocity was attained. Maxim solved the problem in 24 hours with a microscope and a micrometer, showing that the charcoal and sulphur were very finely ground and intimately mixed, while the saltpetre was granular. The problem which was thought to be chemical yielded its secret to mechanical methods of inquiry.

This was not Maxim's only excursion into explosives. The rapid fire of his gun soon obscured the view by a cloud of smoke, and its value was thus quickly reduced. He therefore turned his attention to the production of a smokeless powder. Already something had been done on the Continent. Nobel had taken out patents for mixing nitro-glycerine and collodion cotton, the latter modifying the explosibility of the former. Maxim mixed nitro-glycerine and guncotton, modifying the action of both by the addition of oil. He also devised a means of squirting the plastic mixture through dies in the form of threads or wires. Subsequently, Sir Frederick Abel and Sir James Dewar, working with all the resources of the Government at their command, evolved cordite, which in many important respects resembled Maxim's explosive.

Among Maxim's early inventions was an automatic gas apparatus working with gasoline. Thousands of these were used in the States, but when the electric light appeared the subject of our memoir was among the first to realise its advantages. Many of our readers will remember that the popular cry was for some method of "dividing the electric light." The arc lamp and the Jablochkoff candle were at the first the only means of utilising the dynamo-generated current for illumination, and both were evidently unsuited for interior illumination. Early lamps were made of platinum and platinum-iridium, but the efficiency was poor. Maxim and Edison in the United States, and Swan in this country, turned their attention to the fabrication of carbon filaments, and each had a fair measure of success. The invention, however, which rendered the carbon filaments commercially possible was Maxim's flashing process, in which the filament was glowed in an atmosphere of hydrocarbon. Carbon was thus deposited on the thinnest, that is the ho test and weakest, portion of the filament, building it up to a uniform diameter and finally coating it with a hard metallic-like skin, which gave it strength and elasticity. Maxim's inventions in connection with electric light were very numerous, but most of them have ceased to have any interest, as they were directed to conditions which rapidly disappeared with the improvement of generators and distribution systems.

So far we have been dealing with Maxim's salient inventions. There were many others which would have made the reputation of a smaller man, but which have been dwarfed out of notice. It is beyond the limits of our space to refer to a tithe of them, but it will be interesting to give a brief chronological review of the career of the subject of our memoir. His ancestors were Huguenots and came to England at the revocation of the Edict of Nantes. Early in the eighteenth century they emigrated to Plymouth, Massachusetts, and a hundred years later went to Maine. Maxim himself was born at Sangarville on February 25, 1840, and therefore was in his 77th year at his death. His father was successively farmer, wood-turner and miller, and sent his son, at the age of 14, to a carriage builder. Soon after this he entered his uncle's engineering works at Fitchburg, Mass., and later he was at a philosophical instrument maker's, and also at a shipbuilder's. After a time spent in this way Maxim seems to have led a wandering life for a time, being a bar-tender, a turner, a brass fettler, and a pugilist at various times. Possibly the Civil War rendered it difficult to get steady work, but at the close (1865) he found employment with Oliver P. Drake, and there invented his gas machine. He also perfected an automatic sprinkler, an automatic steam-pumping engine for domestic purposes, and busied himself with feed-water heaters, steam and vacuum pumps, engine governors, gas motors, liquid meters, and apparatus for carburetting air. In 1878 he commenced his work in connection with electric light, and took out patents for electric lamps, dynamos, lamp carbons, regulating mechanism, secondary batteries, and many other things. At this time he was chief engineer to a company formed by Mr. S. D. Schuyler, and in 1881 he represented his firm at the Paris Exhibition. It was at that time he became interested in machine guns, and was introduced to Mr. Albert Vickers, as already explained. Up to that time his inventions had not been remunerative to him on the whole, and he was little better off than in his young days. Possibly the profits of some were swallowed up in perfecting others, while in some cases his inventions were pirated by unscrupulous manufacturers. Once he had settled in Europe he showed no inclination to return to the States, always asserting that the Patent Laws here gave more security to the inventor than did those of his native land.

It would be wearisome to chronicle all the subjects that occupied Maxim's attention during the 36 years he lived here. We have already referred to the principal; of the others, some were successful and some were not. But he was always at work on new things, humorously styling himself a "chronic inventor," and certainly to no one was the term more applicable. The most noticeable feature in his character was his belief in himself. If a thing required to be done he always believed that he could do it, and he never troubled to inquire what methods had been followed by previous experimenters. His line of attack was decided by insight or instinct, and generally it led right to the heart of the subject. Like all inventors, he was an optimist; he discarded his failures, but took great pride in his successes. The honours and decorations he received in most European countries, beginning with the Legion of Honour in 1881 and extending to his knighthood in 1901, were a genuine source of pride to him, and he was always ready to recount his achievements and his triumphs. He was a born *raconteur*, and on one occasion, when he played a practical joke on a large number of military men and artillerists by inviting them to Erith to see a bullet proof breastplate, which turned out to be a $\frac{7}{16}$-in. steel plate, his ability saved him from a very unpleasant quarter of an hour. By a stream of jōkes and humorous anecdotes he kept the attention of his guests until their anger had somewhat cooled, and they were content to leave without displaying the resentment which they felt at the trick put upon them. Probably this was the only time that he ever found himself out of harmony with his audience, for he was an original talker and had an endless fund of amusing tales to illustrate his remarks. His death has removed from our midst a capable engineer, a marvellous inventor, and a fascinating personality.

SILICA REFRACTORIES.

THE subject of refractory materials is so important at present that we do not hesitate to draw attention to some new "Studies of Silica Refractories," although we dealt with the refractory problem at some length in our recent account of the discussion arranged by the Faraday Society. The paper which we wish to notice is to be presented to the American Institute of Mining Engineers in their New York meeting, planned for February, 1917, but is published in advance in the November *Bulletin* of this Institute. The memoir is interesting in two respects. The author, Mr. J. Spotts McDowell, describes experiments of his own which he conducted at the Massachusetts Institute of Technology in continuation of an investigation begun by Mr. Kenneth Seaver, chief engineer of the Harbison-Walker Refractories Company of Pittsburg; the materials were in both cases supplied by this company. Quite as instructive as these experiments is Mr. McDowell's review of the recent literature on the subject, particularly because some of the German publications to which Mr. McDowell refers are at present hardly accessible in this country. The question of the relations between the different modifications of silica, quartz, tridymite and cristobalite, is the first problem discussed.

Mr. C. N. Fenner, of the Geophysical Laboratory, more or less in agreement with Messrs. N. L. Bowen, G. A. Rankin and F. E. Wright, and with Messrs. R. Rieke and K. Endell, distinguishes α and β phases of each of the three modifications of silica. At ordinary temperature the α phase exists alone, and it changes rapidly into the β phase as the temperature is raised. The inversions of the modifications are much slower, and the equilibrium diagram, so far as really established, is very complex. Heated in the presence of a flux, which is rarely altogether absent in natural silica, the silica turns into quartz below 870 deg. C., and further into tridymite and, above 1,470 deg., into cristobalite. In the absence of a flux quartz is transformed into cristobalite direct at 1,250 deg., without the intermediation of tridymite; but quartzite will turn more and more into tridymite after many burnings. These modifications differ in optical and other properties, thermal expansion, &c.; but as the same grain of a brick may contain all the three modifications, the optical examination and its interpretation are by no means simple.

The raw material of the American silica refractory is a quartzite occurring as firm rock and as loose ganister floe and containing more than 96 per cent. of SiO_2; some of the other constituents are necessary to form a bond in the brick. Quartzite with more than 99 per cent. of SiO_2 is unsuitable; a good ganister should contain not more than 1.75 or 2.5 per cent. of alumina and iron oxide (together), a little lime, and not more than 0.5 per cent. of alkali; and should melt about 1,750 or 1,770 deg. C. Some lime is added to the ground pulp, so that the final lime content ranges from 1.5 to 3 per cent. The test specimens of McDowell were three lots of bricks, 9 by 4½ by 2½ in., the material being disintegrated to regular or coarse grind, medium or shape grind, and fine grind; the regular grind would contain 56.5 and the fine grind 41 per cent. of particles passing through 40-mesh screens. The bricks were burned up to six times—other experimenters have gone to higher numbers—at temperatures up to 1,450 deg.; these temperatures were only determined with the aid of Seger cones, however. In apparent density the bricks ranged from 2.229 to 2.277, in open-pore volume from 19 to 28.5 per cent; little is said about these latter tests; the regular grind proved most porous, the medium grind least. Only three bricks of each lot were available for the cross-breaking and crushing tests, for which the American Society of Testing Materials demands five specimens. Looking at the fluctuations in the results obtained, that number is certainly not too large. Uniformity of strength, McDowell points out, is quite as essential as high strength; average values should not serve as a basis for comparison. The uniformity diminished with

repeated burnings, particularly in the cross-breaking tests; the regular grind was most satisfactory in this respect, the fine grind least, whilst in regard to actual strength the regular grind was least satisfactory and the medium grind answered best. A second burning of the brick seemed generally advantageous, a third burning increased the cross-breaking strength of the regular grind; in the other cases the advantage of a third burning was more than doubtful. The alternating expansions and contractions of repeated burnings seem to favour the formation of minute cracks, and for that reason stronger bricks could probably be produced by maintaining the maximum temperature for a longer period in one or two burns. In making the test bricks, the bricks were kept in the kiln for a period of 10 days.

The "spalling" or crumbling of bricks is ascribed to the sudden changes in temperature, especially of the cristobalite, the percentage of which, however, is supposed to decrease with repeated burnings. As ordinarily conducted, the American spalling test consists of heating the bricks repeatedly, cooling in air or in water, and determining the loss of weight. This test is unnecessarily severe, and McDowell, in his tests, placed 16 bricks in a gas-fired kiln, heated them slowly up to 600 deg. C. (the rate of rise being 15 deg. per hour), kept them at that temperature for 3 hours, and rested the bricks on edge on inverted steel pallets, 2 ft. apart, to cool in the air; the diminution in strength of the brick, which did not show any visible shattering, was afterwards determined. Under this treatment the spalling tendency of bricks burned from one to six times diminished with each burning; the diminution was not large, however. The loss in strength was 60 per cent. on the first burning and 45 on the sixth burning, whilst clay bricks (containing silica and 33 per cent. of Al_2O_3) lost only 4.5 per cent. in strength by the same treatment. The interesting point is that the tendency to spalling seemed to increase with the cristobalite contents. Repeated burning appears to favour the slow formation of cristobalite and, later, of tridymite; but the well-known spalling tendency of silica bricks is generally ascribed to the conversion of α into β cristobalite at between 230 and 270 deg. According to Dana, Endell and Fenner, the specific gravities are: quartz, 2.21, tridymite, 2.27, cristobalite, 2.333; above 600 deg. the expansions (Rieke and Le Chatelier) are slight in the three cases, but cristobalite has the highest expansion coefficient. Tridymite, on the other hand, shows the smallest temporary expansion of the silica minerals, while possessing the highest specific volume, the least permanent expansion after repeated burnings and the least tendency to crack on sudden temperature changes. Hence it would appear that the production of tridymite bricks should prove advantageous. Attempts to make tridymite bricks have not been promising so far, however, and the problems remain exceedingly complex. One of the chief reasons is, of course, that silica is a bad conductor of heat, and that refractories are purposely made porous to keep the thermal conductivity down; the temperature changes within the mass of a brick are hence very slow and uncertain.

NOTES.

Propeller Resistance and Ship Resistance.

Some interesting experiments are described in a note contributed to the American Society of Naval Architects and Marine Engineers by Naval Constructor W. McEntee, U.S. In the first series of experiments four model propellers were tested. Of these one was carefully finished smooth all over, and true to pitch and form. The others were castings respectively of bronze, steel, and cast-iron, and were tested in the condition as cast, only rough places being trimmed off with chisel and file, following the usual practice with propellers for the merchant marine. The tests showed that the maximum efficiency of the highly finished propeller was 72 per cent., whilst that of the three left rough was about 63 per cent. The note points out that if vessels remain for any length of time in certain waters there is a considerable accumulation of barnacles and other sea growth on the propeller. Hence a further test was made to determine the effect of such growths on the propeller efficiency. To this end the surface of the highly finished propeller used in the preceding tests was covered with granulated cork and again tested. In this condition its efficiency fell to 36 per cent. In the same note Mr. McEntee describes a test made to determine the "air" resistance of the steam collier Neptune. This boat has much top hamper in the shape of coaling booms and the like, and experience had shown that the power for a given speed varied considerably with the direction of the wind. A scale model was accordingly prepared and tested in a wind tunnel. The tests show that a head wind of 30 miles per hour, with the ship steaming at the rate of 16 miles per hour, increased the power required for the speed from 3,850 effective horse-power to 4,620, or by 20 per cent. Conversely, if the power were maintained constant, such a head wind would decrease the speed attained by 1.9 nautical miles per hour.

Stimulating War Workers.

The exhibition of the official kinematograph films of the "Battle of the Somme" has done much to impress the general public with the realities of modern warfare in all its sanguinary and destructive intensity. And yet, except to the trained observer with keen powers of observation and the mental faculty of making deductions, there is the disadvantage that the full significance of each moving picture could not be fully realised. What was needed for the average spectator was a mentor who had lived through the scenes depicted, who had taken part in the terrible ordeals of battle portrayed, and had experienced the trials and discomforts which are every day the lot of our troops, to "point the moral and adorn the tale" illustrated by the views. With such an accessory the films have an enormously enhanced value as an educational medium. The Vickers Company recognised this fact, and the further probability that special free exhibitions of the films, with a suitable lecture or running commentary, to all their workers in turn, would enable them more directly to realise the connection between their work in the factory and the fighting at the front, the intense importance of adequate supplies in ever-increasing volume of all forms of fighting appliances, and the vital necessity of greater effort and continuous diligence, where such are possible, in order to assist towards early and complete victory. The company therefore arranged with Sergeant F. Ratcliffe Holmes, of the Highland Light Infantry, to deliver such lectures to their workers. He fulfils all the requirements of a mentor as stated by us, since from personal experience he is able to guide the audience in interpreting every incident and appraising every indication of valour of the warriors as well as the importance of the contributions of the workers towards victory. The theme in itself is an epic; Sergeant Holmes in his simple yet forcefully direct diction does it justice, while his blending of the grave and the gay makes the story intensely human to the British temperament. We direct attention to the enterprise in order to impress upon all employers the great advantage of such kinematograph lectures being given free to their workers as a means of impressing upon them the vital importance of their share in defeating our enemies, and of stimulating them to make greater effort and fuller sacrifice in order completely to achieve our aim.

The Higher Training of Women Engineers.

It is being more and more recognised that one permanent change effected by war conditions will be that women will take a larger part in engineering, and that, too, not only in operations requiring a moderate amount of skill, but in the higher ranks where a high degree of training, scientific and commercial, is called for. When one reflects on the ambition of women in medicine, law, and other learned professions, and realises, too, the foothold they have secured in engineering, owing to the war, it is obvious that there must not only be ambition in regard to applied science professions, but also a greater prospect of its ultimate realisation. The Hon. Lady Parsons has, with a skill equal to her knowledge and discrimination, taken up this aspect of the future of women in engineering, and on Wednesday of this week read a paper on "The Prospects for Educated Women in Engineering" at the Women's Institute in London. As a result of close study of the work done in numerous factories, she was able to prove that many women, whose mental faculty had been developed, were able to undertake work of a highly technical character. It was considered, to begin with, that women on munition work would only be entrusted with attendance upon automatic or semi-automatic machines, but Lady Parsons showed that many girls soon acquired sufficient experience to become tool-setters, and that the opposition of the skilled male mechanic to this further inroad upon his domain has been overcome, although with difficulty, in the interests of the full utilisation of man-power. The girls, too, are also able to grind tools; they can centre and finish off the numerous and diverse metal parts allotted to them; they make a beautiful job of silver soldering work; test dynamos; make glucose, requiring great purity, in the laboratory; they effect, too, the numerous finishing processes required for the reflectors for searchlights. In the larger munition factories they turn and finish the steel rings forming part of the breech mechanism of guns, working with the micrometer gauge. They are engaged screwing the breech blocks for howitzers, marking off parts of breech mechanism, and turning and milling the firing pins. They are extensively employed on turbine blading, in the assembling and fitting of electric switchgears, and marking off steam jackets for pumps. In some cases they are engaged in the drawing office on rough design work, requiring far greater ability than in tracing. This, naturally, has led Lady Parsons to consider some definite scheme of higher training for educated women workers. The difficulty in past years was that the girls who graduated in engineering at Cambridge were unable to obtain the required training in factories. Her view is that those girls who desire to continue engineering work after the war should be trained, as with apprentices, either in evening classes or continuation or part-day schools, in order that they may become skilled mechanics, if not scientific engineers in the widest acceptance of that term. It is true, as Lady Parsons pointed out, that a large percentage (in one factory 25 per cent.) of the women have left the shops, finding the work too hard or disliking the life. But there is work suitable for training women engineers and, as Lady Parsons said in conclusion, it rests with themselves whether they are going to make good their position in engineering work, whether they are going to study and prepare so as to grasp opportunities when they come along. "The women engineers have the best chance in the world of practical training now, the time is ripe for study and research, the public generally is well disposed towards women, and the engineering world are ready to appreciate good and original work, whether it is done by man or woman." We have no doubt that engineering employers will welcome this development. It remains to be seen how trade unions will accept what seems to be an inevitable result of war conditions.

Students of the Institution of Naval Architects.—The council of the Institution of Naval Architects is prepared to consider applications from persons desirous of joining the Institution as students. Candidates must be between the ages of 18 and 25 at the time of election, and must be either apprentices, articled pupils, or students in naval architecture or marine engineering. The council administers certain scholarships in naval architecture of the annual value of 100*l.* (tenable for three years), which are offered annually for competition among students of the Institution who are between 18 and 21 years of age. A post-graduate scholarship in naval architecture of the annual value of 200*l.* a year, and tenable for two years, is also offered annually by the Royal Commissioners of the Exhibition of 1851, and awarded on the recommendation of the council of the Institution. Candidates must be British subjects under 30 years of age, and must be nominated for the purpose by the board of the university or college at which they have graduated. The Sir William White Research Scholarship in Naval Architecture of the annual value of 100*l.* has recently been established, and will be thrown open to competition after the conclusion of the war. A gold medal and a premium of books or instruments are offered annually for the best original communications contributed to the Transactions of the Institution by authors who are not members of council. Full particulars may be obtained from the Secretary, Institution of Naval Architects, 5, Adelphi-terrace, London, W.C.

LITERATURE.

Aeronautics. First Annual Report of the National Advisory Committee for Aeronautics. Government Printing Works, Washington. 1915. [SECOND NOTICE.]

In a previous issue (see ENGINEERING, October 27, 1916, page 417) we reviewed the earlier portion of this valuable volume, which was devoted to the discussion of such questions as the stability of machines, the design of stays and the strength of the materials used. The second section of the book reviews the development of engines suitable for aeronautic service and discusses the results obtained in various competitive trials. It is pointed out that though such competitions are of service in the existing state of the art, conclusions based upon the results observed must be accepted with some caution, since each competitor naturally designs the engine he enters to meet the conditions of the test. The resultant order of merit is, however, by no means necessarily representative of the relative value of the engines as applied to actual practical flight. In the early days flight was only rendered possible by drastic reductions in the engine weights. This was often effected by the omission of parts which were really essential to the durability or reliability of the engine. This did not greatly matter at the time, as a few minutes' running sufficed for what was then considered quite a long flight. As aviators became more ambitious, questions of durability and reliability became of greater importance. Even when this stage was reached frequent overhauling of the engines was found to be a first essential to success. Engines were taken down completely and readjusted after as little as 15 hours' running, a work which only highly skilled mechanics could undertake.

Some highly interesting figures as to engine weights have been collected together in this report. The variations are very great, and though this is in part attributable to the use of different types of engine, it would also appear to be to some extent attributable to certain items being included in some cases and omitted in others. Again, some builders estimate their weights on the basis of the maximum power which their engine is capable of developing for a short spurt under favourable conditions; whilst, on the other hand, in the British Government tests the weight per horse-power was based upon the minimum developed during a 6-hour run. The difference is far from insignificant. In the German tests an engine which during any period of the test fell off 15 per cent. on the rated speed was disqualified; but, apparently, in estimating weights per horse-power the rated output of the motor was used. This point must be borne in mind when studying the many figures tabulated in this report. The lightest figure tabulated is for a Gnome engine, which on one rating is credited with developing 1 h.p. under 2½ lb. total plant weight. The lowest figure given for engines with fixed cylinders is 3.05 lb., whilst the minimum for water-cooled engines is 4.20 lb., the highest in the list being 6.8 lb. Engines with cylinders set in line appear to run a little heavier than engines having cylinders arranged on the V principle. From theoretical considerations the weight per horse-power should be less the greater the number of cylinders used to attain a given output; but the figures tabulated show no marked systematic difference of this kind. Some engines with four cylinders weigh less than others with six or eight, but, taken as a whole, the multi-cylindered engines are perhaps on the average a little the lighter.

The report observes that most of the engines make from 1,200 to 1,500 r.p.m. in normal working. A few run at over 2,000 r.p.m., the highest figure being the 2,500 r.p.m. of the Sunbeam engine. It is noted that the output per working stroke of most of the engines varies little until the speed is far in excess of the normal, but a limit is ultimately reached at which the mean torque diminishes owing to the valve and port resistance, and, it is added, to the insufficient speed of combustion. So far as the concluding portion of this observation is concerned, experimental evidence would be of interest, since nothing of the kind has been found by the British Association Committee on Gaseous Explosion. They concluded that as the speed rose the consequent increase in the turbulence of the gases drawn in increased the rate of combustion *pari passu*.

TABLE I.—WEIGHTS OF ENGINE, ACCESSORIES, AND COMPLETE PLANT WEIGHTS PER HORSE-POWER FOR DIFFERENT TYPES OF CONSTRUCTION.

Name and Authority	Engine alone.	Gasoline Tank.	Oil Tank.	Radiator and Connections.	Water.	Muffler.	Total Engine and Accessories.	Gasoline per Hour.	Oil per Hour.	Fuel and Oil for 5 Hours.	Fuel and Oil for 10 Hours.	Plant and Supplies for 10 Hours.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Average values, Bendemann	—	—	—	—	0.63	—	—	—	—	—	—	—
4-cylinder 100-h.p. Benz, Bendemann ..	3.57	0.944	0.084	—	0.626	—	5.224	0.472	0.042	2.57	5.14	10.364
6-cylinder 90-h.p. Daimler, Bendemann	3.75	1.02	0.076	—	0.626	—	5.472	0.510	0.038	2.74	5.48	10.952
4-cylinder 70-h.p. Daimler, Bendemann	4.29	1.01	0.094	—	0.626	—	6.020	0.505	0.047	2.76	5.52	11.540
4-cylinder 100-h.p. Daimler, Bendemann	4.29	0.988	0.080	—	0.626	—	5.984	0.494	0.040	2.67	5.34	11.324
4-cylinder 70-h.p. Daimler, Bendemann	4.74	1.006	0.062	—	0.626	—	6.434	0.503	0.031	2.67	5.34	11.744
6-cylinder 100-h.p. Daimler, Bendemann	4.60	1.056	0.062	—	0.626	—	6.344	0.528	0.031	2.99	5.99	12.33
4-cylinder 60-h.p. Daimler, Bendemann	4.89	1.002	0.068	—	0.626	—	6.576	0.501	0.029	2.65	5.30	11.876
4-cylinder 65-h.p. Daimler, Bendemann	5.09	0.998	0.120	—	0.626	—	6.834	0.499	0.060	2.79	5.59	12.424
4-cylinder 95-h.p. N.A.G., Bendemann..	4.33	0.970	0.076	—	0.628	—	6.002	0.485	0.038	2.61	5.23	11.232
4-cylinder 55-h.p. N.A.G., Bendemann..	4.36	1.038	0.018	—	0.626	—	6.042	0.519	0.009	2.64	5.28	11.322
4-cylinder 95-h.p. Argus, Bendemann ..	3.77	1.060	0.178	—	0.626	—	5.642	0.534	0.089	3.11	6.23	11.872
4-cylinder 70-h.p. Argus, Bendemann ..	4.38	1.176	0.166	—	0.626	—	6.34	0.588	0.083	3.35	6.71	13.058
6-cylinder 100-h.p. Argus, Bendemann..	4.60	1.172	0.134	—	0.626	—	6.532	0.586	0.067	3.76	6.531	13.064
6-cylinder 100-h.p. Mulag, Bendemann..	5.14	1.056	0.042	—	0.626	—	6.864	0.528	0.021	2.74	5.49	12.354
6-cylinder 90-h.p. Schröder, Bendemann	4.65	1.242	0.094	—	0.626	—	6.612	0.621	0.047	3.34	6.68	13.292
6-cylinder 125-h.p. Hall Scott (makers)..	4.32	—	—	0.51	0.32	—	—	0.60	0.03	—	—	—
Average of 6, British Anzani (maker)..	3.7	—	—	—	—	—	—	0.54	0.164	—	—	—
6-cylinder 87-h.p. Benz (maker) ..	4.0	—	—	—	0.138	0.101	—	0.557	0.022	—	—	—
6-cylinder 90-h.p. Wright (maker) ..	5.1	—	—	—	—	—	—	0.53	—	—	—	—
Green, Alexander test	5.46	0.65	0.15	0.76	0.56	—	7.60	0.59	0.175	—	7.65	15.25
Gnome, 1913, Lumet	—	—	—	—	—	—	3.366	0.549	0.255	5.520	11.04	14.41
Gnome, 1911, Lumet	—	—	—	—	—	—	2.88	0.805	2.253	—	10.58	13.46

Air-cooled engines, though they may be made lighter per horse-power developed than water-cooled engines, are generally much more wasteful of fuel and lubricating oil, and this drawback becomes serious if extended flights are to be made. An instructive comparison is made between a 100-h.p. Benz water-cooled engine weighing 4.2 lb. per horse-power and a 70-h.p. Gnome engine for which the corresponding figure is 2.9 lb. The Benz engine consumed 0.472 lb. of petrol per horse-power hour and 0.042 lb. of oil, making a total of 0.514 lb. per horse-power hour. The corresponding figures for the Gnome engine were 0.805 lb. of gasoline and 0.253 lb. of oil, or a total of 1.058 lb. per horse-power hour. Hence for a flight occupying less than 1¼ hours the total weights are less for the Gnome than for the water-cooled engine; but for all longer flights the advantage lies with the latter, as shown by the following table:—

Duration of flight .. hours	0	5	10	15	20
Total weights per horse-power, plant, fuel, and oil for Benz .. .. lb.	4.2	6.77	9.34	11.91	14.48
Total weights per horse-power, plant, fuel, and oil for Gnome .. .. lb.	2.9	8.19	13.48	18.77	24.06

An interesting observation by Bendemann is quoted in the report, to the effect that in the case of aeroplane engines it is sufficient to assume that only 15 per cent. of the total heat supply to the engine must be removed by the radiator. For ordinary motor-car engines the corresponding figure is 30 to 40 per cent., and the difference is attributed to heat losses directly from the jacket and water pipes, or to, for some obscure reason, less heat passing into the jacket from the cylinder. A lighter radiator suffices accordingly, and the report suggests that, taking a line through motor-car practice, the radiator weight should not exceed 0.4 lb. per 1,000 British thermal units dissipated per hour, or for the more efficient engines 0.61 lb. per horse-power developed. The weight of the radiator and connections for the 61.6-h.p. Green engine, which won the Alexander prize, was 0.76 lb. per horse-power. The weight of water carried in this case was 0.56 lb. per horse-power.

We abstract from the report the table above showing actual weights per horse-power of the different components making up the complete power plant for an aeroplane.

The second part of the report on engines consists of detailed discussion of the considerations involved in each element of the design of the engines. Naturally there is room here for differences of opinion, and all may not be inclined to accept in their entirety the whole of the reporter's conclusions. The author of this report, Mr. C. E. Lacke, holds the view that the number of cylinders used should be the minimum required to secure balance and an even torque. He is a strong advocate of the use of silencers, which he states need not increase the back pressure by more than 2 lb., and possibly less. The terrific noise from the powerful engines now used must, he holds, injuriously affect the pilot. It certainly prevents him from detecting incipient engine trouble by the change in the rhythm of the engine, and, of course, warns all interested in the advent of a plane, thus increasing the difficulty of effective military use. He anticipates little further progress in aeroplane construction in the United States unless makers are strongly backed by the Government, which he suggests should conduct annual tests, on the results of which cash bonuses and heavy buying orders should be placed. A laboratory should also, he considers, be established for the development of promising ideas, no matter by whom submitted, and a certain amount of engine construction should be undertaken in Government workshops in competition with external firms. The latter would, of course, require ample safeguards to prevent the discouragement of private enterprise or possible excuse for charges of unfairness.

BOOKS RECEIVED.

United States Bureau of Mines. Bulletin No. 86. *Some Engineering Problems of the Panama Canal in their Relation to Geography and Topography.* By DONALD F. MACDONALD. No. 89. *Economic Methods of Utilising Western Lignites.* By F. J. BABCOCK. Washington: Government Printing Office.

Department of the Interior, Bureau of Mines, U.S.A. Bulletin No. 114, Petroleum Technology. 29. *Manufacture of Gasolene and Benzene-Toluene from Petroleum and Other Hydrocarbons.* By W. F. RITTMAN, C. B. DUTTON, and E. W. DEAN; with a Bibliography compiled by M. S. HOWARD. Washington: Government Printing Office.

Concentrating Ores by Flotation. By THEODORE J. HOOVER. Third Edition. London: *The Mining Magazine*, Salisbury House, E.C. [Price 12*s.* 6*d.* net.]

The Flotation Process. Compiled and Edited by J. A. RICARD, A.R.S.M. San Francisco: Mining and Scientific Press; London: *The Mining Magazine*, Salisbury House, E.C. [Price 8*s.* 6*d.* net.]

Transactions of the Institution of Naval Architects. Vol. lviii. Edited by R. W. DANA, M.A., M.Inst.C.E., Secretary of the Institution. London: Henry Sotheran and Co.

Through French Eyes: Britain's Effort. By HENRY D. DAVRAY. London: Constable and Co., Limited. [Price 6*s.* net.]

Air-Screws: an Introduction to the Aerofoil Theory of Screw Propulsion. By M. A. S. RIACH. London: Crosby Lockwood and Son. [Price 10*s.* 6*d.* net.]

Principles of Oil and Gas Production. By ROSWELL H. JOHNSON and L. G. HUNTLEY. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 16*s.* net.]

"A THOUSAND-AND-ONE USES FOR GAS."—The November issue of this pamphlet, published by the British Commercial Gas Association, 47, Victoria-street, S.W., shows how incandescent gas can be utilised to fulfil the recommendations of the Home Office Committee for the lighting of factories and workshops

THE PARALLEL OPERATION OF ELECTRIC POWER STATIONS.*

By John S. Peck, Member.

(*Concluded from page 519.*)

Fig. 6 shows a method of connecting alternate current and continuous current stations. The arrangement has many possibilities.

Practical Examples.—It is common practice to operate electro-hydraulic systems of the same frequency in parallel, and on the Continent and in America many large transmission networks are supplied from stations located long distances apart. In Great Britain an increasing number of systems of the same frequency are being operated in parallel, but there has been very little done towards linking up systems of different frequencies.

In South Wales a 40-cycle system is operating in parallel with a 50-cycle system through two 500-kw. induction motor-generators. One set has a 40-cycle induction motor and a 50-cycle synchronous generator. The other has a 50-cycle induction motor and a 40-cycle synchronous generator. These sets have worked very well in service, except that the heavy wattless currents taken by the induction motors limit the output of the stations and cables. A synchronous condenser is being installed which may work on either system. There are probably other cases with which the author is not familiar.

In France and in Italy there are some large systems of different frequencies connected through motor-generators, and the author is indebted to Mr. T. Prinetti, of the Società Elettrica Riviera di Ponente, Savona, Italy, for some particulars of a very interesting installation where a synchronous set is used for linking up two very large systems—one of 16⅔ periods and the other of 50 periods. The synchronous set consists of two 10,000-k.v.a. generators, one having 2 poles and giving a frequency of 16⅔ cycles, and the other 6 poles and giving a frequency of 50 cycles. Fig. 7 shows a diagram of connections, from which the magnitude of the system may be seen. Mr. Prinetti says :—

"Synchronising is usually done by first synchronising the turbine with the 50-period part of the plant, and afterwards with the 16.6-period part, the latter operation being very easy. Only from time to time is it necessary to telephone to other stations to adjust the speed.

"It was not necessary to apply any special device to the regulators of the water-wheels. The regulators are of the 'Riva' oil-pressure type, with an hydraulic motor."

In this case the two machines are coupled to a steam turbine. The original plan was to use the set for feeding either or both systems, but as coal is now at an almost prohibitive price is Italy, the set does excellent service as a frequency changer.

Summary.—(1) Polyphase systems of the same frequency may be connected together directly or through transformers, and operated in parallel without difficulty, but where each station supplies its own customers it is desirable to have some form of voltage regulator to permit independent control of the voltage of each station. If the stations are located in the neighbourhood of telephone or telegraph circuits, are connected solidly, and have earthed neutrals, provision must be made to prevent high-frequency currents flowing between the stations.

(2) To interconnect a polyphase and a single-phase system of the same frequency a rotating machine of the phase-converter type or a motor-generator is required if the polyphase system is to be symmetrically loaded.

(3) Systems of different frequencies may be interconnected through frequency changers, sets consisting of two synchronous machines or of one synchronous and one induction machine. The synchronous set is usually the more desirable, since it permits power-factor control and transmits energy in either direction without a change in the speed ratio between the two systems. It is, however, somewhat more difficult to operate, and to prevent danger from overloading it should have a fairly large capacity with reference to the smaller of the two stations which it interconnects. The induction set is much more flexible, and a small set can be used between two large systems, but it requires a considerable difference in speed ratio between the two systems for transmitting full load, and the induction machine takes wattless current from the system to which it is connected.

(4) In certain cases where continuous current is required the rotary converter may be used with advantage as an interconnector between two stations of different frequencies, or between an alternating and a continuous-current system.

In conclusion the author wishes to thank Mr. Prinetti for the interesting information he has supplied, Mr. J. W. Beauchamp for some useful suggestions, and Mr. H. Vickers for help in the preparation of the appendices.

APPENDIX I.

The Effect of Resistance and Reactance upon the Parallel Operation of Alternating-Current Generators.

In a paper entitled "Current-limiting Reactances in Large Power Stations,"† the effect on parallel operation of two alternators by inserting reactance between them was considered.

Where two stations are connected by a cable of considerable length the question of its resistance upon parallel operation must also be taken into account. The following treatment, though very incomplete, will serve to show the general effect of resistance upon the parallel operation of two generators or two generating stations.

In Fig. 8 let OA and OB represent the induced voltages of the two generators, assumed to be equal ;

α the angle of displacement ;
A B the resultant voltage, due to displacement ;
O C the direction of the cross current with reactance only in circuit ;
O D the direction of the cross current with reactance and ohmic resistance in circuit ;
ϕ the angle between O D and the voltage A B which produces it ;
R the resistance in the interconnecting circuit and in the generators ;
L ω the reactance in the interconnecting circuit and in the generators.

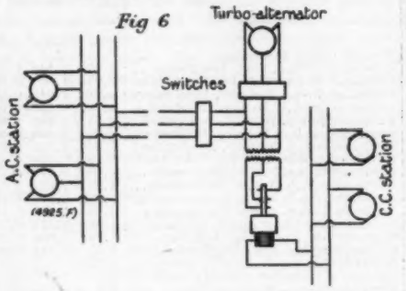


Fig 6

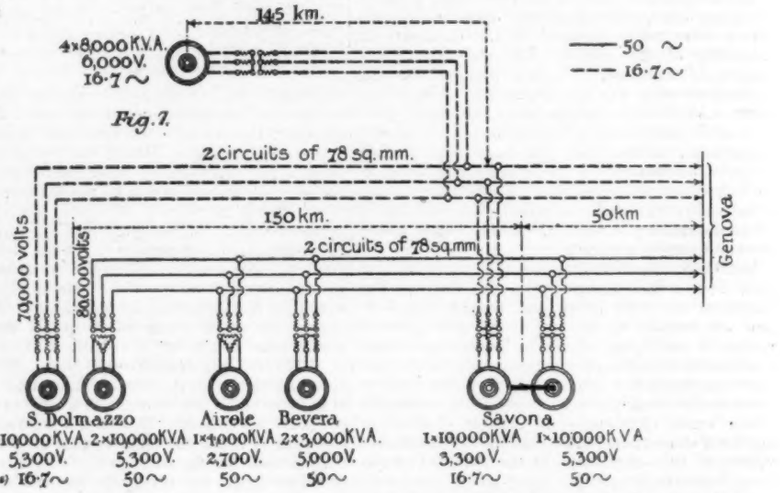


Fig. 7.

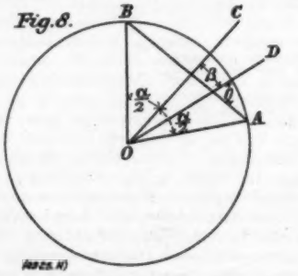


Fig. 8.

Then $$A\,B\,2 = O\,A \sin(\alpha/2)$$

Cross current $$\frac{2\,O\,A \sin(\alpha/2)}{\sqrt{(R^2 + L^2\omega^2)}}$$

Total synchronising power

$$= \frac{2\,(O\,A)^2 \sin(\alpha/2)}{\sqrt{(R^2 + L^2\omega^2)}} [\cos(\alpha/2 - \beta) + \cos(\alpha/2 + \beta)]$$

$$= 2\,(O\,A^2/R) \sin(\alpha/2) \cos\phi\,[2 \cos(\alpha/2) \cos\beta].$$

But $$\beta = (\pi/2 - \phi).$$

Therefore total synchronising power

$$= [2\,(O\,A^2/R) \sin(\alpha/2) \cos(\alpha/2) \cos\phi \sin\phi]\,8$$

$$= (O\,A^2/R) \sin\alpha \sin(2\phi)$$

$$= (O\,A^2/R) \sin\alpha \cdot \frac{2\,L\omega}{\sqrt{(R^2 + L^2\omega^2)}} \cdot \frac{R}{\sqrt{(R^2 + L^2\omega^2)}}$$

$$= 2\,(O\,A)^2 \sin\alpha \cdot \frac{L\omega}{R^2 + L^2\omega^2}.$$

From these equations the following is apparent :—

(1) The synchronising torque has a maximum value when $\alpha = 90°$. This, then, is the critical angle of displacement, as any further displacement will cause the machine to drop out of step.

(2) For any value of α the synchronising torque is a maximum when R = 0.

(3) Without reactance there can be no synchronising torque.

(4) For any value of R the synchronising torque is a maximum when $\sin(2\phi) = 90°$, or $\phi = 45°$, i.e., when $R = L\omega$.

(5) Where R is small as compared with L ω, its effect on the synchronising torque is negligible. Thus, if L = 100 per cent. and R = 25 per cent., the synchronising torque is decreased only about 3 per cent. If R is increased to 50 per cent., the synchronising torque is decreased only about 12 per cent.

The conclusions are, that, for any value of resistance likely to be found in practice, its effect may be neglected.

APPENDIX II.

Method of Calculating the Load on an Induction-Synchronous Frequency-Changer.

Let a, b and c represent the rated outputs of A, B and C respectively (Fig. 4, page 518 *ante*).

p_a, p_b represent the drop in speed (as a fraction of drop when supplying full load) for A and B.

p_c represent the slip of C (as a fraction of full-load slip).

L represent external load on B's busbars.

Assume first that A and B have the same drop in speed when delivering full load, and that this drop in speed equals the slip on C for full load.

Then, neglecting losses.

$$L = b\,p_b + a\,p_a \quad . \quad . \quad . \quad (1)$$

and

$$c\,(p_b - p_a) = a\,p_a \text{ or } c\,p_b = p_a\,(a + c) \quad . \quad (2)$$

From these equations the loads on A, B and C may be calculated.

Assume a = 10,000 kw., b = 5,000 kw., c = 1,000 kw., and L = 5,000 kw. From (1) we have

$$5{,}000 = 5{,}000\,p_b + 10{,}000\,p_a : \text{ and from (2)}$$

$$1{,}000\,p_b = p_a\,(10{,}000 + 1000), \text{ from which is obtained}$$

$p_a = 0.0769$ $\quad a\,p_a = 769$ kw. = load on C.

$p_b = 0.846$ $\quad b\,p_b = 4230$ kw. = load on B.

If A and B have different speed regulations and C has a slip different from the speed drop of A and B, the same formulæ may be used, by assuming the regulation of one station (B for example) as a standard, and increasing or decreasing the ratings of A and C in proportion, as their slip is less or greater than that of B.

For example, assume the speed regulation of B to be 3 per cent. ;

Assume the speed regulation of A to be 2 per cent. ;

Assume the slip of C to be 4 per cent.

Then the loads will be distributed as though speed drops were all equal, and as though the rating of A were 10,000 × (3/2) = 15,000 kw., and that of C were 1,000 × (3/4) = 750 kw. Therefore assume

$$a = 15{,}000, \quad b = 5{,}000, \quad c = 750.$$

From (1) $\quad 5{,}000 = 5000\,p_b + 15{,}000\,p_a$.

From (2) $\quad 750\,p_b = p_a\,(15{,}000 + 750)$.

From which is obtained

$p_a = 0.0416$; 15,000 × 0.0416 = 625 kw. = load on C.

$p_b = 0.875$; 5000 × 0.875 = 4375 kw. = load on B.

If there is a load on the busbars of both stations, then the station which would have the smaller drop in speed for the load connected to its busbars should be taken, and the load on the other station determined for the same drop of speed. The difference between the actual load on the busbars and the calculated load is that which must be distributed between the two stations, and the load on the frequency-changer may be calculated according to the methods given above.

For example, take the conditions assumed in the last example, except that there is a load of 5,000 kw. on A's busbars as well as 5,000 kw. on B's busbars.

Now 5,000 kw. on A gives a speed drop of 1 per cent., and a drop of 1 per cent. in speed gives a load of 1,666 kw. on B. Therefore, the load which must be divided between the two stations is 5,000 − 1,666 = 3,333 kw.

All of the above examples assume a straight-line speed curve, and the same no-load speed on both stations.

* Paper read before the Institution of Electrical Engineers, Thursday, November 23, 1916.

† Journal I.E.E., 1914, vol. 52, p. 520.

THE POWER-FORGING OF CHAIN CABLES.*

By NAVAL CONSTRUCTOR FREDERIC G. COBURN, U.S.N., Member.

THERE has been developed, during the last two years, at the United States Navy Yard, Boston, Massachusetts, a power-forging process for the manufacture of chain cables which has been highly successful; and on account of its success and of the possibilities at present in view this paper has been prepared for the information of the members of this society. It will be remembered that a paper on chain cables was read before this society in December, 1913, by Assistant Naval Constructor J. E. Otterson, United States Navy, his paper being an historical review of the manufacture of chain cables by hand and a statement of the efforts made up to that date to produce chain by a power process. Those who are interested are referred to Assistant Naval Constructor Otterson's paper for a discussion of the relative merits of side and end-welded chain, the function of the stud, breaking and proof stresses, &c. This paper will deal with the progress of the yard in power-forging since the necessity for its development arose.

No great mechanical difficulty was experienced in the manufacture of chain by hand until diameters as great as 2¾ in. were reached; even that size was fairly well handled; but when the 3-in. cables were taken up, serious difficulties were encountered on account of the size of the metal, the mechanical difficulties involved, and the very hard labour required of the chainmakers' helpers. It was not only difficult to get chainmakers to make good chain; it was exceedingly difficult to get them to attain a satisfactorily high rate of production and regularity of attendance.

When the Panama Canal Commission went into the market for the guard chains for the Panama Canal, which were 3 in. in diameter, the Boston Navy Yard was the only plant that could reasonably approach the requirements of the Commission. A great part of these cables were made with open links—that is, without studs—and hence was inherently weaker than stud chain; and as the welds were not well made the ultimate breaking stresses obtained were low. Whereas 525,000 lb. ultimate breaking strength was required for stud-link chain and desired for 3-in. open-link chain, it was found necessary to reduce the requirement to 500,000 lb., and subsequently to 450,000. Private chainmakers were given contracts. Their chain was not so good as that made by the hand-welders at the Boston Navy Yard; it lacked the uniformity in shape and size of link and was not so well welded. In the photographs (see illustrations on page 532) of Panama chain test triplets, it will be seen how irregular in shape the hand-welded links were, how they were reduced in diameter next to the weld, and how obviously inferior they are to the power-welded links. Yet they were submitted as test triplets by a private manufacturer. The hand-welded triplet No. 2 failed at 364,000 lb.; No. 1, at 390,000 lb.; but the power-welded triplet, No. 3, went to 532,000 lb. before failure. One power-welded triplet went to 586,000 lb. without breaking and was then removed from the machine for exhibition (Figs. 1 to 7, page 532, inclusive).

Deficiencies of Hand-welded Chain.—The causes of the inferiority of hand-made welds become apparent after experience in the testing pit. The helpers cannot hit hard enough with their sledges to drive the two scarfs together. The welding surfaces are not smooth, because they are formed by peening; pockets are thus formed, which retain slag; and the hammering does not work out this slag. Thus the weld is incomplete. Sometimes a pocket as big as a half-dollar is found, occasionally open to the sea by a small crevice. Fractures have been produced in proofing old chain which showed that not over 10 per cent. of the surfaces was welded; only the strength due to form, assisted by the tacking together of the scarfs, had held those links intact in service. In the large chain it was impossible to finish the inside of the link at the welded end, thus leaving a hollow and reducing the sectional area.

Another serious defect in the hand-welded chain is the wasting of the material, in the fire, just back of the weld. There is no way to make this up, except to increase (uniformly) the diameter of the metal in order to have the full diameter in this quarter. In the power-forged link, however, the metal is upset slightly before scarfing, completely avoiding this deficiency. To sum up, the hand-made welds are not complete, not uniform, and not reliable.

As stated above, the need of a power-forging process had been foreseen at the Boston Navy Yard. Naval Constructor E. F. Eggert, United States Navy, had some years ago prevailed upon the master shipsmith, Mr. William Paul, to attempt the development, with the results given in Assistant Naval Constructor Otterson's paper. The first attempt was made with a Bradley helve hammer, because that hammer hits a rapid, elastic blow, which appeared to simulate the blows of the hand sledge. That method was found impracticable, and resort was then had to ordinary steam hammers. All the experiments had been made on the 3-in. size, and at the time referred to there were available the dies that had been made for the purpose. Briefly, the process consisted of shearing the bolt to length as usual for the hand-welders, in a large power shears; bending up the end of the bolt in a 6-in. Ajax upsetting machine; putting on the scarf in a 2,500-lb. steam drop hammer; bending the link by hand around a mandrel; welding the link under a 350-lb. single-frame steam-forging hammer; and then, in another heat, finishing the link under dies fitted to a 3,000-lb. double-frame forging hammer; trimming off the "flash" by hand. While this process made chain that looked good, it would not meet the breaking stress requirements.

Heat Treatment the Solution.—When the matter was taken up in July, 1914, this was the status. It was found, however, that no very considerable amount of chain had been made by this process; so the master shipsmith was instructed to set up his dies and start out as if to make chain, with the idea that possibly a little practice might bring the quality of the chain up to requirements. This was done. However, the breaks were still below requirements, the fracture in every case occurring in the welded quarter of the link and showing rather coarse granular structure.

At a loss to explain the matter, since the welds seemed to be good, and the hammering on the link appeared to make a better link than a hand-welder could make, consideration was given to the possible benefits of heat treatment. It was found then that there was no literature on the heat treatment of wrought iron. The iron in use had a carbon content of about 0.10 per cent., which is not much below that of dead soft steel; but, again, no literature on the heat treatment of low-carbon steel could be found. Nor was the shop equipped for accurate experimental heat treatment. However, a way was found to heat-treat one or two test triplets, and it was found that, even though the carbon content was so low, the iron was very responsive, and that heat treatment made good chain.

It had been suggested by one or two experts who had been consulted that the chain be quenched from a temperature above the critical point, and, if possible, vibrated, this being recommended with a view to stiffening and strengthening it. The opposite kind of treatment, however, was that which was found to be successful. The reason is that the severe hammering applied to the link by the steam hammer stiffens it in the welded quarter, and a partial annealing is required to soften it enough to make the quarters deform under the shearing stress which obtains there. This permits the total stress to run up until a fracture can be obtained by a combination of shear and tension. The practice now is to give the chain an air quench from a temperature slightly above the upper critical point.

The hand-welders had not been successful with the open-link chain. The breaking stress requirement for the stud-link chain was 500,000 lb. The open-link chain required for the Panama Canal could not be brought up to that standard, and the inspector had been accustomed to pass chain that broke as high as 450,000 lb.; but it was shortly found that by the power-forging process, with heat treatment, the open-link chain could be made to stand stresses as high as 550,000 and 560,000 lb. The experiments being thus successful, authority was given by the Panama Canal Commission, July 30, 1914, and the Navy Department, Bureau of Construction and Repair, July 31, 1914, to proceed with the power-forging process of manufacturing chain.

The equipment in use was, of course, more or less improvised; and during the past two years there has been a constant, almost daily, development in the equipment and its use. New hammers, especially designed for this service, have been purchased, and have proved highly satisfactory in service. The methods of heat treatment have been vastly improved. Standard thermocouples have been manufactured and installed; potentiometers purchased, to use instead of galvanometers; and the use of the equipment studied, with the result that in the large, car-bottom, over-fired, chain-annealing furnace, where finished chain is treated, nine thermocouples are installed, and it is found practicable to keep the temperature variation, between different parts of the furnace chambers, within 10 deg. C.

Now on Manufacturing Basis.—During the fiscal year ended June 30, 1916, there were manufactured at the Boston Navy Yard practically 9 miles of chain, of diameters 2½ to 3½ in., inclusive. No better confirmation of the statement that the problem has been solved can be asked for. The cost of 3½-in. chain, for example, has been practically 6 dols. per foot, or 6 cents per pound. Even this cost is considered high, because the process is not yet wholly beyond the experimental stage; that is to say, that a very great improvement will be made, probably in the near future, in the methods of bending the link, in trimming the link after welding, and in other directions, so that the cost will shortly recede to a considerable extent. Even if the cost were greater for properly made and welded chain, it would be offset by the gain in amount and regularity of production and in quality. Taking the case of 3½-in. chain, for example; when the 3½-in. iron for the Pennsylvania cables was first delivered to the Boston Yard—those being the first 3½-in. cables made—two chainmakers' gangs were assigned the job of making a test triplet each. Each gang took a whole day to make its triplet, and laid off the next day, claiming that they had worked so hard that they were incapacitated and required a day's rest. It was stated that a production of three links in two days for one gang would be about the best that could be expected of hand-welders. At that rate it would take a single gang seven years to make the cables for a battleship of the Pennsylvania class. The present production is at the rate of 20 links per welding gang per day, every day. Were the hand-welding process still in vogue at the Charlestown Navy Yard, a shop of approximately four times the area at present engaged in chainmaking would be required in order to equal the rate of production now obtained. This estimate is in proportion to the difference in production, which takes into account the difference in space requirements for the hand-welders and the power-welders. Figs. 8, 9, page 532, give two views of a test triplet of 3½-in. stud chain. The required ultimate strength is 612,000 lb., which is uniformly exceeded.

When the 3-in. open-link chain for the Panama Canal was being manufactured, the cost per link, direct labour, ran about 1.37 dols. by hand, and about 1.20 dols. by power. The job was wound up so quickly that there was not time to bring about cost reductions; but on 3-in. stud-link chain made for the Commission, the figure of 86 cents. was attained. This was subsequently still further reduced. A brief description of the process follows, illustrated by engravings of the machines and their operations. (See pages 532, 542, 543.)

Shearing the Bolt.—The first operation is that of shearing the bar iron into lengths, or bolts, one bolt for each link (Fig. 10, page 532). These bolts, after shearing, are put in steel baskets, so that they can be transported by crane. The bar iron itself, when delivered into the shop, is placed on skids at the height of the bottom of the shear blade, so as to reduce the labour involved in cutting it up. Where five or six men were formerly employed to hold up the bolt while one operated the shear, one now does all the work; and instead of having to truck the bolts two or three at a time to the upsetting machine, they are now carried in these baskets a ton or more at a time by the overhead electric travelling crane.

Scarfing the Forged Bolt.—The next process is that of upsetting and scarfing. Two special furnaces were built for this process, and so installed as to put a furnace, an upsetting machine, and a drop-hammer practically in the arc of a circle. It was intended to have the trimming press for the scarfing operation in this circle, but it was impossible to do so without making extensive alterations, which up to the present time have not been practicable.

The furnace is charged with from 6 to 12 bolts, depending upon their diameter. When heated for a length of about 1 ft. the bolt is placed in the upsetting machine; when the treadle is depressed the cheek-blocks come up and hold the shank of the bolt, and then the header comes up and upsets it. The appearance of the bolt is then as indicated in Fig. 11, page 542.

In the same heat the bolt is taken directly from the upsetting machine to the 2,500-lb. steam drop-hammer, where the scarf is put on it. The appearance of the bolt after this operation is shown in Fig. 12, page 542, immediately after which it is taken to the trimming press and the flash from the drop forging removed. The other end of the bolt is then put in the furnace, with the view of scarfing it in the same way as the first end was scarfed.

Bending the Bolt.—The scarfed bolt is then placed in a basket similar to that in which the bolts were brought to the drop-forge plant, and the basket when filled is carried by the overhead crane to the link-bending plant. This plant consists of a 100-ton hydraulic forging press. The press has three capacities—40 tons, 60 tons and 100 tons. Ordinarily only the 40-ton cylinder is used. The process of bending the link is illustrated in Figs. 13 and 14, page 542. The press is of the bulldozer type, so commonly seen in railroad forging shops, and was purchased with a view to using it for bending links and other hydraulic forging purposes.

The mechanism for bending the link was designed and developed at this yard. It is mounted on a sole piece, which is bolted to the bed of the press. It consists of a stationary mandrel of the size and shape of the inside of the bent link. The bolt is clamped into the press with one of the scarfed ends fitting one end of the mandrel snugly, as shown in Fig. 13, page 542. When the press comes forward, the small wheel shown in the figure as nearly touching the link simply wipes the bolt around the mandrel, leaving it in the position shown in Fig. 14, page 542. This small wheel is on an arbor which is attached to a toothed wheel revolving about the geometrical centre of the mandrel. This toothed wheel is rotated by a sector which rotates about an arbor fixed to the sole piece of the mechanism, being pushed and pulled by a link secured to its end and to the head of the press. As soon as the chain link has been wiped around the mandrel the scarfs are pried apart by a man with a crowbar.

Welding the Link.—The description of the process of welding the link begins at the completion of a link in the chain. Immediately thereafter a helper brings a link from a preheating furnace—that is, a furnace in which the scarfed and bent link has been brought to a bright red heat—and threads it into the last link made, as indicated in Fig. 15, page 543. The chain being made is carried on a low jib crane with a trough running from the end of the jib to a point on the mast about 4 ft. from the ground. This crane is very easy to slew, and handles the chain in a very satisfactory manner indeed. The matter of the development of a suitable crane was one of the knottiest problems, peculiarly enough, that had to be solved.

The new link having been threaded in, the crane is swung over to the large hammer. Here it should be said that each welding plant consists of two hammers, and the plant in the engraving, which was the first plant used at this yard, consists of a 3,000-lb. double-frame steam-forging hammer, and a 350-lb. single-frame steam-forging hammer, both hammers being operated, however, by compressed air. The 3,000-lb. hammer is fitted with dies similar to drop-forging dies, in which there is an impression of the shape of the link. It should be noted that this is not the shape of the completed link; its shape has to be such that when the link is stretched to proof stress in the testing pit it will take the shape specified on the standard plan.

It is to these dies that the threaded link is brought, and the link, which has been spread apart at the hydraulic press enough to permit of threading it, is closed down. The crane is then swung over until it plumbs the fire, and the link is lowered into the fire for the first welding heat. The oil forge used is of the ordinary type, except that

* Paper read at the 24th general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1916.

POWER-FORGING OF CHAIN CABLES.

(*For Description, see Page 541.*)

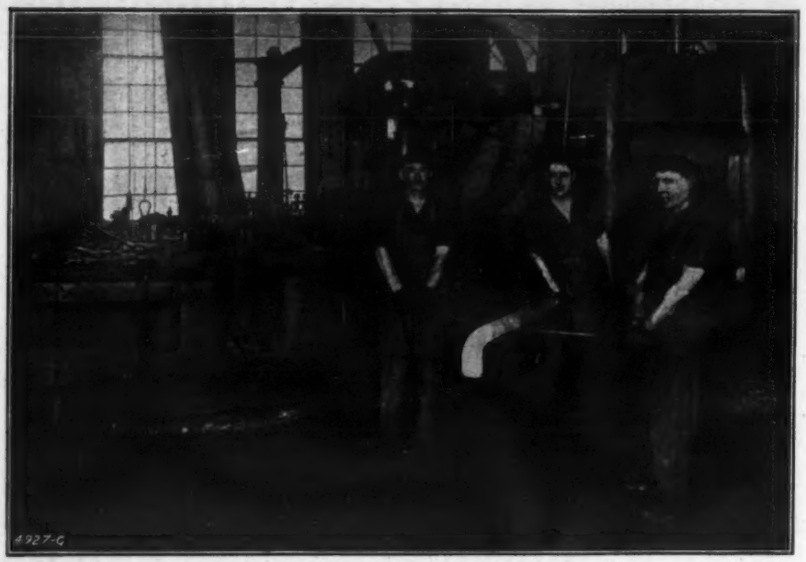


FIG. 11. UPSETTING THE BOLT.

FIG. 12. SCARFING THE BOLT.

FIG. 13. BENDING THE BOLT; READY TO BEND.

FIG. 14. BENDING THE BOLT; PRYING SCARFS APART.

POWER-FORGING OF CHAIN CABLES.

(*For Description, see Page* 541.)

FIG. 15. THREADING THE PREHEATED LINK.

FIG. 16. FIRST WELDING OPERATION ON DOLLY DIES.

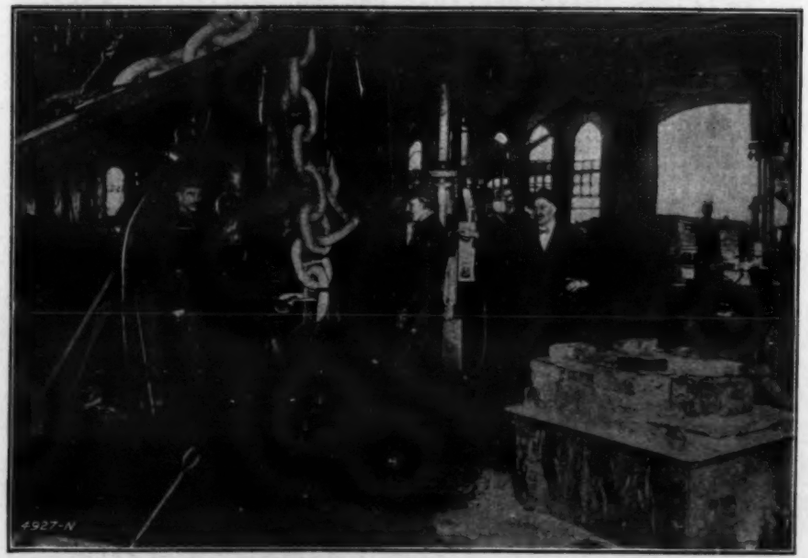


FIG. 17. SECOND WELDING OPERATION, TEMPORARY PLANT.

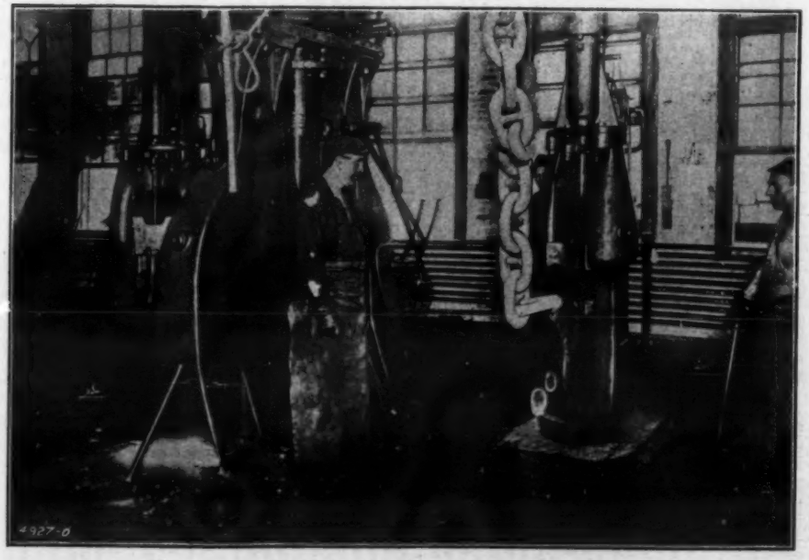


FIG. 18. NEW DOUBLE WELDING PLANT.

it has an unusually large area of flame duct and combustion chamber, in order to reduce as much as possible the velocity of the gases, as it was found early in the development of the process that small areas with high velocities caused localised heating and serious wasting of stock.

The mechanic watches the link and feels it occasionally with a pricker, and when hot enough the members of the gang go to their stations. One man is stationed to operate the hammers. As only one hammer need be operated at one time, one hammer runner is sufficient. One man operates the hoist and swings the crane. The mechanic and his principal helper grab the link with a special pair of tongs, and the fifth member of the gang tends the fire, helps with the chain under the hammer, helps to swing the crane, and assists in setting the stud.

When the link comes out of the fire it is swung over to the 350-lb. hammer, which is fitted with special dies with horns on them, these being called "dolly dies." Under this small hammer the scarf is thoroughly hammered in such a way as to work out the slag from between the welding surfaces, and to make as thorough a weld as is possible. Experiments indicate that this is the most important process of the welding, although it has also been indicated by experiments that it alone does not suffice. Fig. 16, page 543, shows the link on the heck of the dolly die, after this welding process. It is then very thoroughly welded, but is not in perfect shape. It is, therefore, swung back into the fire, and when again at welding heat is put in the dies of the 3,000-lb. hammer and struck several times on both sides. This forms the link perfectly and completes the welding, being especially valuable in making the tips of the scarfs stick. Fig. 17, page 543, illustrates the link after this second welding operation.

Trimming.—This welding process leaves a flash, both on the inside and outside of the link, and this flash is cut off by the use of a hot chisel struck by two of the helpers in the gang.

Setting the Stud.—The operation of setting the stud is such a simple one that it scarcely needs description. The link is swung over to the 3,000-lb. hammer, is put between the dies, standing on its side, the stud is gripped in a pair of tongs and held while the hammer pushes the link together enough to grab the stud.

The New Welding Plants.—The plant illustrated in the above-mentioned figures is the one on which the process was developed. It is still being kept at work, manufacturing 3¼-in. chain.

Each of the new plants consists of one double-frame 1,800-lb. steam drop-hammer, to take the place of the 3,000-lb. hammer illustrated in the figures, and on each side of this hammer is a 250-lb. single-frame forging hammer, one being left-handed, the other right-handed. The dies under the 250-lb. hammers are similar to those shown on the 350-lb. hammer. The dies under the 1,800-lb. hammer are like those shown for the 3,000-lb. hammer, being fitted with impressions on both sides. Thus the arrangement is such that one gang may work on one side of the 1,800-lb. hammer and another gang on the other side, each having its own crane, fire and 250-lb. hammer, and dividing the cost of the 1,800-lb. hammer between them. One of these plants is illustrated in Fig. 18, page 543.

Economic Implications of this Development.—It is interesting to note the economic significance of this power-forging process of making chain, as it is an excellent illustration of the division of labour which always results in the application of power for operation. Where one gang performed the operations of scarfing, bending, welding, finishing, &c., it was impossible to substitute a machine for the gang. But when the process was divided into its integral parts, then it was found that each little part was a simple one, to be done over and over again, and lending itself to the application of power. It has also this significance—that where the hand-welding process required a high-grade mechanic on each operation, this process required a high-grade mechanic on only one operation—that of welding—the other operations are so simple that a helper can be used, the helper being carefully taught the particular part of the process that he will have to perform. For example, the shearing of the bar is done by a helper; also, the bending of the links is done by helpers; the upsetting and scarfing operations are performed by fourth-class mechanics who were helpers and who have been trained to do this particular work. They were rated from helpers because the work is somewhat above that which would be normally expected of a helper.

Development of Equipment and Men Necessary.—The 3,000-lb. forging hammer and the 350-lb. forging hammer shown as used in the manufacture of 3¼-in. chain were standard forge-shop equipment; but their limitations were discovered at an early date. The welding process required a self-contained hammer, in order that the dies may always be in alignment. The standard types of drop-hammers are not satisfactory, because there is not sufficient width between the legs. It was therefore necessary to obtain special drop-hammers, made up with the frame of a forging hammer, the cylinder and top tie-plate of the drop-hammer, and a special anvil like that of a drop-hammer, only wider and lighter. The falling weight was made as small as practicable for a machine of the size required. The special drop-hammer used for the second process of welding is shown in the final figure of the series. The small hammer is a 250-lb. forging hammer, with a special frame, giving unusual height and clearance between the centre of the piston rod and the inside of the frame. For this, also, the falling weight was made as small as practicable. Similarly, the cranes used to handle the chain were especially designed. It is not only necessary to handle the link when it is being welded; the chain already made must be taken care of. The duty required of the air hoists on these cranes is very exacting.

All the experimental work was done with cast-iron dies, because cast-iron dies are cheap and could be readily made from moulds of the shapes desired to be forged, and as experimental work went along new and improved dies could be furnished promptly, the success of this work being due to the ingenuity of the master shipsmith, Mr. Paul. All the early dies, of course were made by "rule of thumb" and by a process of trial and error. There was a continual process of trying and fixing dies going on, and the development was necessarily delayed by broken cast-iron dies, &c. As the art progressed it was taken out of the "rule-of-thumb" class and put on an engineering basis, for which the credit goes to Mr. W. B. Bradford, in charge of the plant draughting.

Steel dies were then put in service. Experimental comparison was made of cut dies *versus* cast-steel dies, in which contest the latter won, being cheaper and lasting quite as well. At the time this paper was written a pair of cast-steel dies had been in service 24 hours per day for almost every working day over a period of 11 months, and they are still in good condition.

When the design of the dies was put on an engineering basis the work was greatly simplified. At present, if a new size of chain is to be made, the dies are all designed in the drawing office, the designs sent to the pattern shop, patterns made, the dies cast and machined, and when put in the hammers produce chain which meets test requirements. In the early part of July, 1916, the Bureau of Construction and Repair inquired whether 3½-in. chain cable could be made if required for the new capital ships, and the yard was able to reply by return mail that this large cable could be made without difficulty.

The development of equipment—hammers, dies, &c.—was no less difficult than the development of skilled help. As the process was begun at a time when the chainmakers were on strike, the services of shipsmiths and blacksmiths were requisitioned, on account of their knowledge of the use of hammers. The extraordinary shortage of skilled labour, brought about by the business conditions in the country during the time when this process was being developed, made it necessary to use all obtainable shipsmiths on regular shipsmithing work, and it early became necessary to make mechanics out of unskilled material. The scarfing process requires drop-forgers. It has been found to be no great task to make a good enough drop-forger out of any reasonably intelligent helper; it has also been found that men could be graduated from this work to regular drop-forging work without difficulty, and some eight or ten skilled drop-forgers were thus developed to make the studs required for the chain. In a similar manner helpers were trained to the other operations of the process, until at present the skilled mechanics are all recruited from the force of helpers. There are always a number of helpers anxious to learn the business, and the practice is made of keeping one or two on hand, ready to step to the fire in case of defection of any regular operator. This has been one of the great advantages, from an operating viewpoint, of the new process.

Shipbuilding in Sweden.—The Finnboda yard, near Stockholm, has decided to construct a new slip, capable of accommodating vessels 375 ft. long and of 5,000 to 6,000 tons. The necessary blasting operations will be commenced shortly, and the work is expected to be so expedited that the first keel can be laid in the summer of 1917. The first boat to be built will, it is stated, be only 250 ft. long.

Germany and Dutch Shipyards.—Dutch yards, says a Danish correspondent, have been informed by the German authorities that they will be put on the German black list if they repair Norwegian vessels, whether the work is carried out with German material or not. For Danish and Swedish vessels special permission has to be obtained. In the case of vessels being built in Holland of German materials permission for export has to be obtained, and no such permission will be available for vessels built for Norwegian account. A Danish steamer, Rosenborg, which came to Rotterdam for repair, had, at the time of writing, been waiting a week for such a German permit.

Nickel Production in Canada, 1914.—According to the preliminary report on the "Mineral Production of Canada during the Calendar Year 1914," by Mr. John MacLeish, a considerable portion of the mining and smelting operations in the Sudbury district of the Canadian Copper Company was closed down on the declaration of war, and though operations were partly resumed, the output of the year was greatly reduced. The Mond Nickel Company, on the other hand, having increased the capacity of its smelter at Coniston, nearly doubled its output. The nickel-copper ore is converted into a Bessemer matte containing 77 to 82 per cent. of the combined metals; the matte is shipped mainly to New Jersey by the former company and to Wales by the latter; the former company also makes some Monel metal (a nickel-copper alloy) directly, without refining either metal. 947,053 short tons of ore were smelted (partly after roasting) and 46,396 tons of matte produced, containing 28,895,825 lb. of copper and 45,517,937 lb. of nickel; the production of 1913 had been only a little larger, but the matte had been richer in nickel; this had not been so in previous years. Some nickel oxide (301,312 lb.) was recovered in the Cobalt district. More nickel reaches the United Kingdom through the United States refineries than is exported directly from Canada.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall Street, London, E.C.

Federated Malay States.—According to the Chief Secretary's Report for 1915 on the Federated Malay States investigations have been made with a view to improving the landing and shipping facilities at Prai, and a report on the proposed works has been drawn up by a firm of consulting engineers for the consideration of the Government. The works recommended are the construction of a pier, 1,200 feet in length; an extension of the pier up the river to form a deep-water wharf; a further extension to form coaling berths; and the dredging of the river. The estimated cost of these undertakings is 864,250*l.*, exclusive of equipment, which will cost about 95,000*l.*

New Zealand.—H.M. Trade Commissioner in New Zealand has forwarded an extract from the local press, from which it appears that the Wellington City Council has approved a scheme for the construction of a lift system between the lower levels of the city and Wellington terrace. The scheme provides for an inclined lift to be carried on reinforced concrete trestles. The office of H.M. Trade Commissioner in New Zealand calls attention to a notice which appeared in the official *New Zealand Gazette* to the effect that, as a result of a poll of the ratepayers of the borough of Masterton (North Island), it has been decided to borrow the sum of 32,000*l.* for the extension of the existing drainage scheme.

Australia.—The Sydney Office of H.M. Trade Commissioner in Australia has forwarded a copy of the specifications, drawings, conditions of contract and form of tender in connection with a call for tenders by the Deputy Postmaster-General, Sydney, for the supply, delivery and erection at the Telegraph Office, Armidale, N.S.W., of an oil engine and generator, switchboard and accumulators. Tenders will be received at the office of the Deputy Postmaster-General, Sydney, N.S.W., up to December 14.

Chile.—The *Diario Oficial* publishes the text of a Law dated September 4, authorising the Chilean Government to arrange for the execution, by means of a public call for tenders, of port improvement works at Antofagasta. Tenders are to be invited in Chile, Europe and the United States within a period of three years. The cost of the works is not to exceed 1,700,000*l.*, payment to be met either by the issue of Treasury bills or by raising a loan. Article 5 of the Law authorises the Government to set aside up to 300,000 pesos gold (about 22,500*l.*) for preliminary expenses in connection with the construction of the port and the branch line which will connect with the Longitudinal Railway. The *Diario* publishes a Decree, dated September 7, authorising the formation of a company at Santiago, to be known as the "Compañia de Petróleos Riqueza de Magallánes," to acquire and work certain petroliferous mining rights in the Territory of Magellan. Amongst the objects of the company are the following:—The carrying out of exploitation and boring operations on the properties acquired; the preparation and sale of petroleum and its products; the construction of roads, railways and pipe lines for the conveyance of the products of the mines and the transport of goods required; erection of buildings and installation of plant required for the preparation for industrial use of the raw products obtained. According also to the *Diario*, permission has been granted to Señor Victor Leon Nuñez to utilise the waters of the Rio Chillan, at the rate of 5,000 litres per second, for the production of power required in connection with the electric lighting of the town of Chillan. Plans of the works to be carried out must be submitted for the approval of the Government within a year from the date of the concession.

Japan (Corea).—H.M. Consul-General at Seoul reports, under date October 7, the publication in the local press of the following projected enterprises at Chemulpo:—(1) Application for permission to form a match manufacturing company, with a capital of 500,000 yen (about 51,000*l.*), is shortly to be filed. It is estimated that the output of the company will be equivalent to about half the annual requirements of Corea, viz., 9,000 tons. (2) A petition for the establishment of a dock company, having a capital of 150,000 yen (about 15,000*l.*), was presented on October 5.

Ceylon Railways.—The length of railway open for traffic in Ceylon at the close of September, 1915, was 602½ miles, as against 672 miles at the corresponding year of 1914. The increase was due to the opening of a section of a line to Chilaw. In the course of 1914-15 rolling-stock was increased by 18 new passenger and 186 new goods vehicles, including a number of tank wagons. The total expenditure to the close of September, 1915, including additional accommodation and improvements, amounted to 7,858,452*l.* The Chilaw line was approaching completion in 1915, and it has been opened to Kochchikade for all descriptions of traffic. Steady progress was made with the Pelmadulla and Badulla extensions, especially on sections between Ratnapura and Dela and between Bandarawela and Ella. Work is in progress on Colombo station extension, and a large broad-gauge goods shed and connecting sidings have been brought into use. Earthwork is in hand on a main line duplication between Ragama and Veyangoda. A survey from Chilaw to Puttalam has been commenced, and a survey connecting the harbour line with the railway, *via* Mutwal, has been completed.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

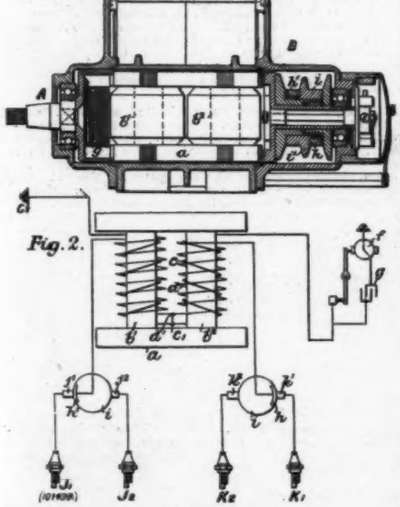
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

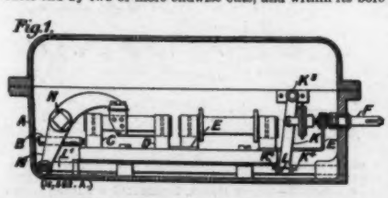
ELECTRICAL APPARATUS.

101,439. A. H. Midgley and C. A. Vandervell and Co., Limited, Acton Vale. High-Tension Magnetos. (2 *Figs.*) March 4, 1916.—The armature *a* has two cores b^1 and b^2, each of which carries half of the primary and half of the secondary winding *c* and *d* respectively, these windings being wound so that the fluxes in the cores b^1 and b^2 due to the primary current are in parallel with each other, and that the two free ends of the secondary winding become of the same polarity, as is well known. The middle point c^1 of the primary winding is connected to the middle point d^1 of the secondary winding, one end of the latter being earthed at d^2, and its other end being earthed through an

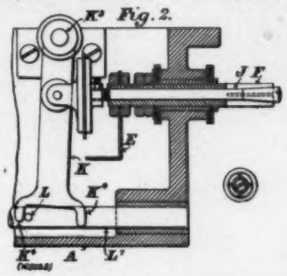


interrupter *e* operated by a cam *f* and shunted by a condenser *g*. The condenser *g* is arranged, according to this invention, at the driving end A of the magneto. The two ends of the secondary winding *d* are connected to two contact segments A and A^1 mounted on a ring *i* of insulating material provided with a flange i^1 and mounted on the shaft of the magneto at the end B. The contact segments A^1 and A come simultaneously into contact with brushes j^1 and k^1, and after half of a revolution simultaneously into contact with brushes j^2 and k^2, the brushes j^1 and j^2, k^1 and k^2 being connected with the sparking plugs J^1 and J^2, K^1 and K^2 respectively. (*Accepted September 27, 1916.*)

16,502/15. Mavor and Coulson, Limited, and W. Lawrence, Glasgow. Electric Switches. (7 *Figs.*) November 23, 1915.—The invention relates to electric switch appliances of the plug and socket coupling junction box type. The live conductor B passes into the box C and is connected to the terminal of the live element C of the switch. From the dead element D of the switch an extension conductor E extends to a plug F projecting from the outside of the box A, on to which a socket at the end of the dead conductor is adapted to be applied. The plug F is hollow and longitudinally divided for a distance from its outer end by two or more endwise cuts, and within its bore a



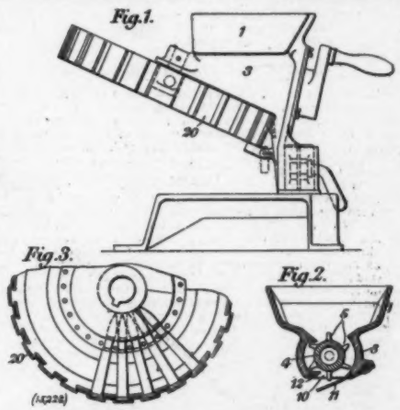
spindle tapered at its outer end is fitted and so connected with the switch-operating gear that as the switch is closed the spindle is drawn in and expands the segmental parts of the plug F. The spindle is connected at its inner end to a rocking lever K, suitable insulation being introduced between the inner end of the spindle and the lever. The rocking lever K, which is fulcrummed at K^5 at a distance from one side of the spindle, is formed at its opposite end with two tappet jaws K^4 spaced apart, adapted to be engaged by a tappet pin L carried upon a reciprocating rod L^1 which derives motion from a lever M operated from the switch shaft N on which the knife element is mounted. By placing the tappet jaws K^4 at a distance apart the final movements only in the reciprocation of the rod L^1 operate to move the expansion spindle, so that in closing the switch the plug F is



expanded in the final part of that movement, and in opening the switch expansion is removed as the final movement of the switch takes place. (*Accepted September 27, 1916.*)

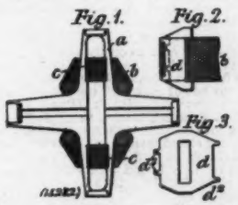
GUNS AND EXPLOSIVES

15,220/15. The Birmingham Small Arms Company, Limited, and G. Norman, Birmingham. Machine Guns. (9 *Figs.*) October 28, 1915.—This invention relates to loading devices for the magazines of automatic machine guns of the kind in which a grooved rotatable feed wheel is employed to convey the cartridges from a hopper to the magazine, and refers to loading devices applicable for use in loading magazines of the circular pan or rotating drum type. According to this invention, a longitudinal grooved sprocket feed wheel 4 of taper formation is employed and is rotatably mounted in a conically-shaped body part 3 at the underside of a hopper 1 adapted to feed the cartridges



one by one into the longitudinal grooves or recesses formed by the teeth 5 of the sprocket wheel. The underside of the conical body has rotatably attached thereto the magazine pan 20 and is provided with an outlet 10 and guide projections 12 and a guide plate 11, which plate directs the cartridges into the radial recesses in the magazine pan; the parts being so disposed and arranged to permit of the teeth of the sprocket wheel successively engaging each cartridge entering its radial recess or housing in the magazine pan, so that the latter is caused to positively rotate to a position ready to receive the next cartridge. (*Accepted September 20, 1916.*)

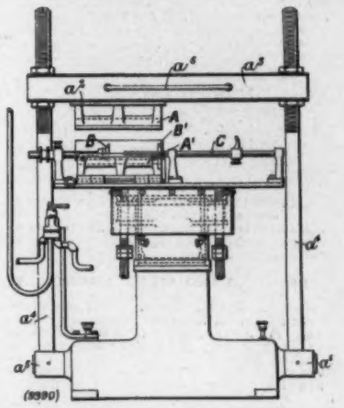
15,262/15. A. W. Showell, and H. G. Lines, Birmingham. Cartridge Clips. (17 *Figs.*) October 29, 1915.—The cartridges of quick-firing shrapnel shells and the like are each provided with a four-armed clip to protect the cap of the cartridge and facilitate the handling of the cartridge, the clip having attached thereto a webbing strap, handle or loop. *a* is the four cartridge clip and *b* is the webbing strap which is threaded through slots *c*, *c*, in two of the arms of the clip *a*, the parts of the strap *b* crossing on the outer side of the clip in the well-known manner. The two



ends of the strap are brought together on the trough-shaped side of one of the arms of the clip *a* and are secured together by a metallic fastener *d* shown to a larger scale in Figs. 2 and 3. The ends of the webbing strap *b* are brought together and threaded through the slot near the middle of the fastener, the parts of which, on either side of the slot, are doubled on the webbing strap *b*. Teeth d^2 are formed on the two ends of the fastener, and these are so bent when the fastener is doubled on itself as to enter the webbing of the strap and thereby more securely grip the strap. (*Accepted September 20, 1916.*)

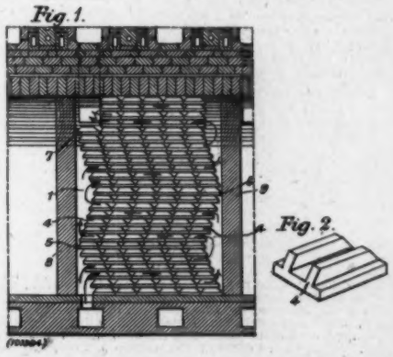
MINING, METALLURGY, AND METAL WORKING.

9,990/15. J. J. Warren, Preston, W. Valentine, and Leyland Motors (1914), Limited, Leyland. Core-making Machines. (3 *Figs.*) July 9, 1915.—According to this invention, two portions A, A^1 of a core-box are arranged to receive relative movement in a direction towards and away from each other, and in conjunction with such portions are two ends B, B^1 which are arranged to occupy any desired distance apart for producing cores of different lengths, a vent or other rod C or rods being guided to pass through the core to form a vent or other aperture or apertures. The lower portion A^1 of the core-box is secured to a plate which is hinged to a rising and falling table. The upper portion A of the core-box is attached to a plate a^2 that is carried by a frame a^3. The latter is adjustably



mounted on two arms a^4 that are pivoted at a^5 and is provided with a rail a^6 to enable the upper portion of the core-box to be moved into and out of alignment with the lower portion, stops being provided for arresting the movement of the arms a^4 when the upper portion A comes into alignment with the lower portion A^1. (*Accepted August 16, 1916.*)

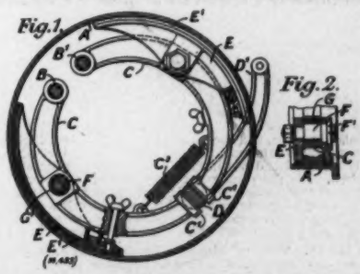
101,394. British Coke Ovens, Limited, and F. M. N. Schuster, London. Regenerative Coke Ovens. (3 *Figs.*) May 5, 1916.—A regenerator 1 for regenerative coke ovens has its chequer brickwork 4 built up in zig-zag formation so proportioned that certain desired rows, such as 5, 6 and 7, abut against the end walls 8 or 9 of the regenerative chamber; the rows abutting alternately first on one side and then on the other.



The baffles or partitions thus formed in the chequer brick structure extending from the walls of the regenerative tunnel are such that the gases passing through the flues of the ovens are constrained to pass alternately horizontally in the one direction entirely through one series of flues and then horizontally in the other direction through another series of flues. (*Accepted September 20, 1916.*)

MOTOR ROAD VEHICLES.

14,483/15. C. H. Roe, Whitkirk, and The R. E. T. Construction Company, Limited, London. Brakes. (2 *Figs.*) October 13, 1915.—A is a brake drum. Pivoted to the axle casing at B and B^1 are two levers C, each provided at its other end with a cap or shoe C^3 which co-operates with a cam D capable of being partially rotated by a lever D^1 forming part of the brake-operating mechanism. The two caps C^3 are kept in close contact with the cam D by means of a spring C^5. At a suitable point on each lever C a brake shoe E is pivoted and is provided with a friction surface E^1. As the brake shoes are thus pivoted to



the levers C, the pressure of the whole surface of the brake shoe on the brake drum tends to be equalised when the cam D is turned. As shown in Fig. 2, the pivot pin passes through the side members of the brake shoe E and is formed with an eccentric portion F rotatable in a bush G in the lever C. At one end the pin is provided with a hexagonal head F^1 which fits into a correspondingly shaped recess in one side of the brake shoe E, the other end of the pin being fitted with a nut. After loosening the nut sufficiently the pin can be withdrawn far enough to allow of the hexagonal head F^1 to be disengaged from its recess, and

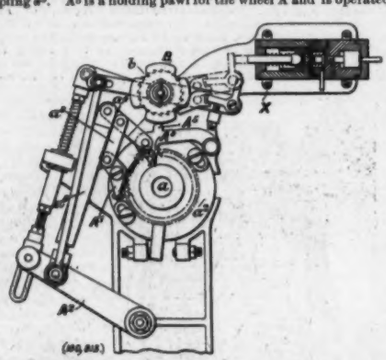
then the pin may be turned through 60 deg. and again drawn home by tightening the nut F2. Owing to the fact that the portion F is eccentric this partial rotation of the pin within the bush G will effect an adjustment of the position of the brake shoe E relatively to the lever. (*Accepted September* 27, 1916.)

16,450/15. Brown Bayley's Steel Works, Limited, and T. H. Sanders, Sheffield. Laminated Springs. (3 *Figs.*) November 22, 1915.—The plates *a* of a spring are swaged at *f* on both sides and are machined out between the swaged portions, leaving shallow slots *b* in both sides of the plates. The plates are

separately inserted in the buckle *c*, and a packing plate *a* of the full width of the spring plates taken across the swaged portions, or of slightly greater width, is driven in and secured by a screw. The projections *f* abut on the edges of the sides *c*1 of the buckle. (*Accepted September* 27, 1916.)

PRINTING AND ALLIED MACHINERY.

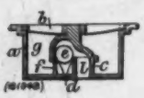
160,815. R. C. Elliott, and The Lanston Monotype Corporation Limited, London. Automatic Type-Casting Machines. (5 *Figs.*) April 13, 1916.—The object of the invention is to provide in an automatic type-casting machine a repeat casting mechanism controlled by the record-strip or pattern, so that a single signal in the record-strip will control the production of a successive series or a predetermined number of casts from the same matrix. According to the present invention, the repeat mechanism, which is controlled by a special signal in the record-strip, operates to interrupt or suspend the feed of the strip for a predetermined number of cycles of the machine, and permits the feed to be resumed after the desired number of casts has been made from the selected matrix. A is a toothed wheel mounted upon the shaft *a* of the feed pin-wheels. A1 is the driving pawl mounted on a ring *a*2 which receives an oscillating motion from a rocking arm A2 through links *a*3, *a*4, and a resilient coupling *a*5. A3 is a holding pawl for the wheel A and is operated



from the link *a*5. The pawl A5 acts normally as a holding pawl between the feed strokes of the pawl A1 until the repeat signal is presented. Mounted upon an extension of the frame X is a cam B, which has notches *b*, in accordance with the predetermined number of casts which each repeat signal is intended to denote. When one or other of the notches *b* is over the projection A6 on the pawl A5 the latter is free to respond normally to the action of its driving mechanism, but when the normal surface of the disc B is over the projection A6 the pawl A3 is locked in engagement with the wheel A, and its driving mechanism operates without moving the pawl. Such action is permitted by the resilient coupling or spring box *a*5. The suspension of the feed has the result that while the matrix carrier remains in the position to centre over the mould the matrix the signal for which is presented concurrently with the repeat signal, the casting mould dimensioning and type delivery mechanisms pursue their usual functions. (*Accepted September* 27, 1916.)

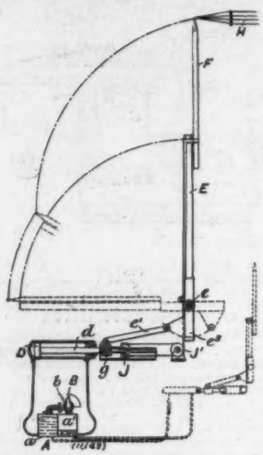
SHIPS AND NAUTICAL APPLIANCES.

101,949. J. Stone and Company, Limited, Deptford, and J. E. Wimshurst, London. Draining Ships' Holds. (3 *Figs.*) August 18, 1915.—The apparatus comprises a casing *a* furnished with a removable grating *b* and an internal casing or part *c* provided with a valve seat *d*, a ball valve *e* and a radial opening *f* for the water which has passed through the grating *b* into the annular chamber *g* between the outer casing *a* and the inner casing *c*. In the construction shown, the grating holds the valve



chamber in place, and the removal of the grating discloses the valve resting on its seat, thereby permitting of the valve being easily removed and the interior of the casing being cleaned, if required. *l* is the passage for the discharge of water into the bilge. As soon as there is a sufficient head of water in the casing, the pressure of the water against the valve *e* raises or pushes it off its seat and the water flows past the valve and down the outlet passage *l* into the bilge. (*Accepted August* 16, 1916.)

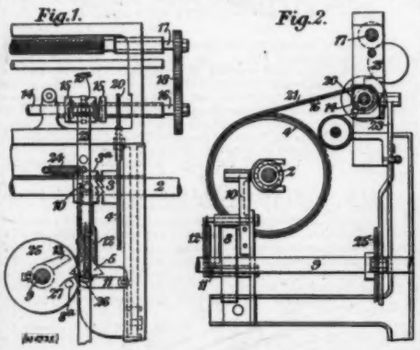
11,143/15. Vickers, Limited, London, and J. McKechnie, Barrow-in-Furness. Folding Collapsible Masts. (1 *Fig.*) July 31, 1915.—This invention relates to folding collapsible masts employed in connection with wireless installations on submarines. A is a reservoir divided into two pressure chambers *a*, *a*1 supplied with oil. C is a cylinder connected at its ends to the chambers *a*, *a*1. D is a piston. E is the lower mast. F is an upper mast or topmast arranged to slide upon the mast E. Compressed air is supplied through the pipe *b* to either chamber *a* or *a*1 according to the position of a valve B, so as to force the oil into either end of the cylinder C, which is kept full. In the position shown in full lines, the masts E and F are up, the oil from the chamber *a*1 having been forced into the cylinder C at the last operation so as to move the piston D to the left. The mast E is pivoted at *e* and is operated by the piston D through the rod *d*, crosshead *g* and connecting rod *c*1 attached to the lower end of the mast socket *e*5. The topmast F, to the upper end of which the aerial wires H of a wireless installation may be secured,



is arranged to slide on the mast E. The mast F is raised by a wire rope passing over pulleys on the top of the mast E and two multiple sheave blocks J, J1, the sliding block J of which is connected to the crosshead *g* by the sheave pin passing through a slot in the crosshead. (*Accepted August* 9, 1916.)

TEXTILE MACHINERY.

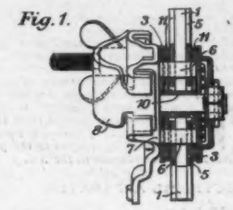
101,375. John Dewhurst and Sons, Limited, and W. Preston, Skipton. Yarn Spooling Machines. (2 *Figs.*) March 13, 1916.—This invention relates to mechanism for starting or re-starting the thread guides at any point on the barrel of the spool. 2 is the driving shaft; 3, 3*a*, two members of a clutch mounted on the shaft, of which the part 3 carries a chain wheel 4 and is loose on the shaft, and the other part 3*a* slides on and is driven by a feather key in the shaft. 5 is the clutch lever. 8 is a cam mounted on the shaft 9, which shaft can be geared to the shaft 2 through the clutch member 3*a*. The portion 3*a* of the clutch is controlled by the lever 5, which is coupled to a shunt bar influenced by a spring 10. When in gear the camshaft 9 is rotated for one revolution whilst the nicking and ending operations are performed. Before the completion of this revolution the internal face of the cam 8 on the shaft 9 comes into contact with a bowl on the clutch lever and, moving it, disengages the clutch 3*a* from the gearing connecting the shafts 2 and 9, so that the shaft 9 ceases to be driven. The shunt bar is latched by a retaining catch 11 whilst spooling is taking place, and when the spools have the required length of yarn wound on the catch is liberated, allowing the shunt bar to throw the clutch into gear and again drive the camshaft 9 for

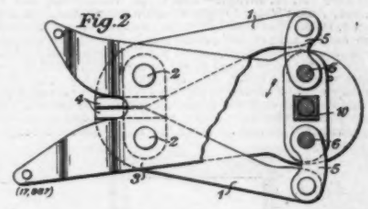


one revolution. As the cam 25 on the shaft 9 rotates it pushes out a bowl 26 and clutch lever 23, thus disconnecting the spindle-gearing shaft 14 from the second spindle 16 by throwing a sliding clutch member 15*a* out of gear with the clutch portion 15 fixed to the shaft 14 and into gear with the clutch portion combined with a chain wheel 20, which is loose on a spindle 16. Then the tappet 13 comes into contact with and depresses the retaining catch 11, freeing the clutch lever 5 and allowing the plate spring 10 to force the clutch 3*a* into engagement with the clutch 3, carrying the chain-wheel 4, and by means of the chain 21 to drive the chain-wheel 20 and rotate the second spindle 16, which, through the train of gearing 18, gives motion to the traverse screw 17, and so moves the traversing thread guides to the point desired before spooling begins. Before the spooling re-starts, the action of the bowl 8*a*, on the cam 8, pushes back the clutch lever 5 and allows the spring 12 to re-latch the retaining catch 11 and to lock the clutch 3*a* out of gear with the clutch 3. Almost at the same time the bowl 26 enters the recess 27 on the cam 25 and allows the spring 24 to disengage the sliding member 15*a* from the clutch part 15 on the chain-wheel 20, and engage with the other member 15 on the spindle-gearing shaft 14, thereby starting the spooling operation with the thread guides set in the desired position. (*Accepted September* 20, 1916.)

MISCELLANEOUS.

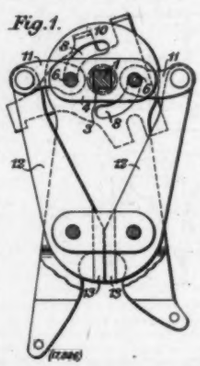
17,887/15. Charles H. Pugh, Limited, G. F. Bull, and A. L. Green, Birmingham. Wire Cutters. (3 *Figs.*) December 22, 1915.—The wire cutter comprises a pair of lever members 1 pivoted at 2 between a pair of side plates. The shorter arms of the levers are formed into cutting jaws 4, which are arranged to be closed together by the opening of the longer arms. These arms are operated by links 5 connected to their outer ends and pivoted to pins 6 carried by the member 7 of a hinged clip 8, which is adapted to be secured around the end of a rifle. The member 7 is pivoted to the side plates 3 by a central bolt, the pins 6 passing through curved slots in the inner side plate. On engaging the cutters with the wire and partly rotating the clip by turning the rifle upwards the cutting jaws 4 will be closed together, through the medium of the links 5, and the wire severed. To relieve the pins 6 from the strains to which they would be subjected the centre bolt is provided with a loose square-sectioned sleeve 10. Mounted upon the opposite ends of the sleeve 10 are

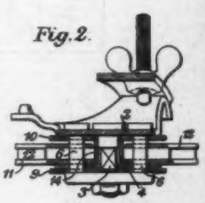




two plates 11, the plates being formed with central square-sectioned holes which fit closely over the ends of the sleeve so that they are prevented from rotating upon the latter, whilst the said plates are formed near each of their ends with circular holes which are arranged to fit over the pins 6, the one plate 11 being arranged to couple together the bottoms of the said pins, whilst the other plate is arranged to connect together their outer ends. (*Accepted September* 20, 1916.)

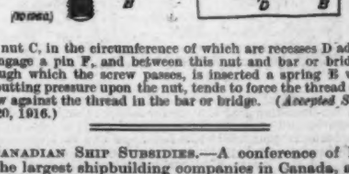
17,886/15. Charles H. Pugh, Limited, and G. F. Bull, Birmingham. Wire Cutters. (6 *Figs.*) December 22, 1915.—The rotating centre pin 1 carried by the clip 2 (which is secured to the rifle) is formed with a square or other non-circular part 3, upon which is loosely mounted a link 4 having a correspondingly shaped opening to engage with the square 3. The outer ends of the coupling plate 4 are provided with circular holes which engage with the outer ends of the usual actuating pins 6, 6, carried





upon the clip 2 upon opposite sides of the centre pin 1 and which work within curved slots 8 in the side plates 9, 10. The strains imposed upon the actuating pins are by this means transferred through the coupling plate 4 to the centre pin 1 in the form of a torsional strain upon the latter. 14 is a loose distance sleeve. The coupling plate 4 comes upon the outside of the pair of links 11 connecting the actuating pin 6 to the corresponding lever arm 12 (carrying the cutting jaw 13). (*Accepted September* 20, 1916.)

101,360. Marconi's Wireless Telegraph Company, Limited, and R. D. Bangay, London. Lock Nuts. (2 *Figs.*) January 24, 1916.—The object of this invention is to provide means for locking a screw, with which it may be possible to alter the adjustment of the screw without impairing the efficacy of the lock. According to this invention, a screw A is locked by means



of a nut C, in the circumference of which are recesses D adapted to engage a pin F, and between this nut and bar or bridge B, through which the screw passes, is inserted a spring E which, by putting pressure upon the nut, tends to force the thread on the screw against the thread in the bar or bridge. (*Accepted September* 20, 1916.)

CANADIAN SHIP SUBSIDIES.—A conference of heads of the largest shipbuilding companies in Canada, acting in conjunction with past presidents of the Canadian Manufacturers' Association, has been held at Montreal for the purpose of formulating a memorandum outlining a plan of Government ship subsidies, which is to be laid before the authorities at Ottawa.